Agriculture and
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The Innovators
ROOTED in SCIENCE

The History of Research Branch from 1986 to 2011

Editors: Yvon Martel, Jean-Marc Deschênes and Nathalie Corbeil

Canada

The Innovators - Rooted in Science, The History of Research Branch from 1986 to 2011

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Tribute to the Assistant Deputy Ministers, Research

Dr. Edward LeRoux	1978–1986
Dr. Arthur Olson	1987–1991
Dr. Brian Morrissey	1992–2000
Dr. Bruce Archibald	2003–2004
Dr. Marc Fortin	2006–2011

And for serving in acting capacity:

Dr. Ian de la Roche	1986
Dr. Gordon Dorrell	2001–2003
Dr. Yvon Martel	2005
Ms. Jody Aylard	2011

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Message from the Minister

For more than a century, Agriculture and Agri-Food Canada has worked with farmers to help them produce food, fight pests and diseases, and grow better crops. The innovative spirit of those whose efforts helped prairie settlers produce an abundance of wheat in a harsh Canadian climate remains just as vigorous today in laboratories and fields across this great country. Thanks to its scientific progress, Canada is a world leader in innovative agricultural products. Our agri-food sector is now Canada's leading manufacturing employer and an important driver of our economy. Our exports help contribute to Canada's role and image as a major trading nation by providing safe and high-quality foods to nations around the globe.

Scientific discovery and innovation remain key to the success of the agricultural sector. It has been predicted that by 2050, global food production will need to double in order to be able to feed the world's growing population. To meet this challenge, we need to continue our long-standing tradition of innovation. We will need new scientific discoveries and close collaboration among academia, the provinces, industry, and the international community.

The past has shown us that scientific discovery can help us overcome great challenges and create new opportunities. The Government of Canada will continue to look to science to bring real results for our farmers and the sector. Thanks to the talent and expertise of our scientists and employees we can all look forward to more exciting agricultural advancements and a prosperous agriculture industry for another 125 years!

Gerry Ritz
Minister of Agriculture and Agri-Food Canada
and Minister for the Canadian Wheat Board

Message from the Deputy Minister

One year after the signing of the *Constitution Act of 1867*, the Department of Agriculture was created and received broad legislative authority, including agricultural research. Eighteen years later, in 1886, the *Experimental Farm Stations Act* allowed for the establishment of the Department's first five experimental farm stations. It is, therefore, with great pride that we can celebrate our long involvement in research and development.

For the first Deputy Minister of Agriculture, Joseph-Charles Taché, and the 20 others that followed him, research and science has always been at the heart of the Department's mission. Throughout my 20 years in various roles at Agriculture and Agri-Food Canada, I have witnessed its value to producers, industries and Canadians, along with its benefits to trade and commerce.

Over the years, collaboration and partnerships with producers and industries as well as with provinces, universities and international organizations has had a major impact on scientific and technological development. They have fueled the success of Canadian agriculture both at home and internationally.

Commemorating the history of research in the Department allows us to understand the vital role that we play in Canadian agriculture and agri-food, and leaves us confident in our ability to contribute new knowledge in the future—knowledge that will continue to improve the sustainability of Canadian agriculture.

Suzanne Vinet
Deputy Minister
Agriculture and Agri-Food Canada

Foreword

Everyone benefits from knowing the evolution of agricultural science, and it is important to learn about our long and proud history. The 125th anniversary of the Department's research role in Canada is a milestone to reflect on.

This book presents this journey of Research Branch, mainly through the last 25 years, from the perspective of multiple authors who are all employees of the Department. It brings into focus how the management of research and science have kept pace with the changing needs of the agriculture and agri-food sector in Canada in the 21st century. It also precedes the 2012 creation of the new Science and Technology Branch, which integrates the former Research Branch, Pest Management Centre and Agri-Environment Services Branch. By bringing together all of our expertise into the Science and Technology Branch, we are providing producers and industry a single point of access to AAFC's science and technology expertise and to the information and sustainable solutions they require.

The numerous achievements of research over the years can be attributed to the hard work of the dedicated scientists and employees. Their contributions have helped make Canadian agriculture a success, well recognized nationally and internationally.

It is commendable that 70 employees, along with many other collaborators, devoted their time and efforts to tell the story as they lived it. We would like to thank all of the authors and collaborators for making this publication possible, and we express our gratitude to Dr. Yvon Martel and his team for their leadership and guidance.

Siddika Mithani
Assistant Deputy Minister
Science and Technology Branch

Gilles Saindon
Associate Assistant Deputy Minister
Science and Technology Branch

Preface

On the eve of the 125th anniversary of the advent of federal agricultural research in Canada, the Assistant Deputy Minister of Research Branch, Dr. Marc Fortin, wanted the year 2011 to be a commemoration for employees, stakeholders and Canadians so that they would be aware of this important milestone.

Adopting the theme *Rooted in Science - Innovating for the Future*, the celebration focused on three main initiatives: the recognition of achievements with the preparation of a poster, videos and communication initiatives; the recognition of employees with an award entitled *Tribute to our Employees*; and the publication of our history with preparation of this document.

Following Dr. Fortin's departure in March 2011, Ms. Jody Aylard was named acting Assistant Deputy Minister, Research and played a key role in the commemoration of the 125th year during her tenure. She was active in the numerous celebrations and visits that took place across Canada and internationally.

This book focuses on the history of Research Branch and its research establishments over the past 25 years. It follows *One Hundred Harvests*, Dr. Tom Anstey's history of the first one hundred years of research, published in 1986; and precedes the 2012 transformation integrating Research Branch and Agri-Environment Services Branch to create Agriculture and Agri-Food Canada's new Science and Technology Branch.

I would like to express my sincere appreciation to all the authors and collaborators across Canada for their invaluable contribution and to the dedicated team of Jean-Marc Deschênes, Nathalie Corbeil, Bernard Vigier, Taunya Goderre and Janet Dowell for their meaningful involvement in the preparation of this book. Thank you to Sandra Weinheimer for the review of the English version and to other Communication and Consultation Branch colleagues for their precious assistance. Special thanks to Bernard Vigier for translating the document from English to French and to Carmen Turcotte and Christiane Dufresne for the in-depth revision of the French text.

Yvon Martel

Introduction

Agriculture has been an integral part of the history of Canada. Growth in food production in order to feed a burgeoning population has been a historic preoccupation. But agronomic conditions have been difficult, from the dry, harsh climate of Western Canada to the excess water and variable soil conditions found in Eastern Canada. Nationwide, the growing seasons are short and the winters very cold. Canada needed a hero, and that hero was science. In 1886, the Canadian government established the first five experimental farms, after which federal agricultural research was rapidly organized and expanded throughout the country. Research covered a wide spectrum of disciplines, from soil science to plant production and protection, to animal science and food science. In 1959, an already well-established science capacity at the Department of Agriculture became Research Branch.

Governance within Research Branch has evolved to meet the changing needs of producers and industry. Beginning originally with the management of the experimental farms, it has undergone several reorganizations in order to consistently remain relevant and productive. Research Centres were established and mandated to carry out the policies of the Department focusing on the needs of the sector. Knowledge and technologies for soils, plants and animals were provided to the producers—the main stakeholders of the Department.

This book presents the history of the Research Branch of Agriculture and Agri-Food Canada (AAFC) for the years 1986 to 2011. It provides a short summary of the first 100 years of Federal agricultural research, followed by a thorough exposition of the history of the past 25 years. It documents the evolution of the governance of Research Branch itself as well as the history of each of the research sites in existence in 1986. It explains how these multiple locations changed to become the Research Branch of 2011, with its nineteen Research Centres. It also presents a list of research highlights for each site, summarizing their large and numerous scientific achievements.

Chapter 1, Research Branch Headquarters

The Development of Agricultural Research in Agriculture and Agri-Food Canada

Manmahipal Ahara, Science Policy Advisor, Research Branch, Ottawa

Shortly after Confederation, having recognized the central role that agriculture would play in its economic, social and cultural development, the Canadian Government established a Department of Agriculture. With the emergence of agriculture as a federal concern, the government began to consider establishing a national institution for agricultural research. In 1886, John Carling, Minister of Agriculture, introduced a bill, An Act Respecting Experimental Farm Stations to establish five experimental farm stations in various regions of Canada. The bill received royal assent on June 2, 1886. The Experimental Farm Stations Act established five experimental farm stations in Nova Scotia, Manitoba, the Northwest Territories (later Saskatchewan), British Columbia; and one in Ottawa for the provinces of Quebec and Ontario known as the Central Experimental Farm. Other farm stations and science organizations were created in subsequent decades. A major reorganization in 1959 led to the establishment of Research Branch.

The history of agricultural research in the federal government began with the *Constitution Act, 1867*, which identified agriculture as a jurisdictional domain. The following year, the young country of Canada, recognizing the importance of agriculture to economic, social and cultural development, created the Department of Agriculture.

Advances in science had been very slow before the 19th century, but as the century progressed, proponents of agricultural reforms sought to develop better farming methods through mechanization and the application of science—especially chemistry and scientific techniques—to agriculture.

The first agricultural research in Canada took place in 1854 on the model farm of an agricultural school in Sainte-Anne-de-la-Pocatière, east of Quebec City. The farm was established by the priest François Pilote, with the objective of transferring new knowledge to regional farmers. Other agricultural schools opened in eastern and western Canada soon afterwards.

Despite these early developments, there was a need in the 1880s for agricultural knowledge across the country. Parliamentary attention to agriculture had been gradually increasing and the government had begun to focus on the need to improve agriculture. New settlers from the east, many of them recent immigrants from Europe, began to move westward. They had limited experience in agriculture and were unfamiliar with the soil and hostile climate of their adopted homeland. The existence of unfamiliar conditions required new knowledge and new agricultural methods.

In June 1884, the Minister of Agriculture, John Henry Pope, appointed James Fletcher as Honorary Entomologist for the Department of Agriculture. Mr. Fletcher worked as an assistant in the Library of Parliament and had become the unofficial advisor on insects to members of Parliament.

One Wednesday afternoon in January 1884, George-Auguste Gigault, Member of Parliament for Rouville, Quebec, rose in the House of Commons to beg for help for Canada's farmers. Though eighty percent of Canadians lived from the land, the agriculture sector had been struggling for the previous fifteen years. Gigault reminded his audience that "...agriculture is the basis of public prosperity." and concluded his short speech by expressing hope that "...the Federal Government with the mighty resources at its disposal will find the means to propagate the agricultural knowledge of which our farmers are in such great need."

Parliament quickly appointed a select committee to determine the "best means of encouraging and developing the agricultural industries of Canada," with Gigault as chair. The committee wasted no time, completing its report by March 1884, and recommending both the creation of a central bureau of agriculture and the establishment of experimental farms where staff would develop and introduce new plant varieties, compare various fertilizers, and undertake "careful investigation into the origin, distribution and habits of insects injurious and beneficial."

On November 2, 1885, Professor William M. Saunders of the Western University of London, Ontario (now the University of Western Ontario) received a letter at his London, Ontario home informing him that the federal Minister of Agriculture, John Carling, required his services for "the purpose of establishing an experimental farm" in Canada. Professor Saunders was considered the pre-eminent agriculturalist in the country at the time, possessing expertise in botany, plant hybridization, entomology, chemistry, pharmacology, horticulture and animal husbandry. He traveled to many agricultural land-grant colleges in the United States and conducted lengthy interviews by letter with agricultural researchers around the world to produce a report to the Minister entitled: *A Report on Agricultural Colleges and Experimental Farm Stations with Suggestions Relating to Experimental Agriculture in Canada*.

Acting on this report, Agriculture Minister John Carling introduced an *Act Respecting Experimental Farm Stations* on April 30, 1886. The legislation received royal assent on June 2, 1886, and Canada's experimental farm stations were born, with William Saunders as the founding director. The Act established five experimental farm stations: in Nappan, Nova Scotia; Brandon, Manitoba; Indian Head, Northwest Territories (later Saskatchewan); Agassiz, British Columbia; and Ottawa for the provinces of Quebec and Ontario, which is known as the Central Experimental Farm. These farm stations, administered from Ottawa, were charged with promoting agriculture "by the dissemination of useful and practical information" derived from research concerning the relative value of breeds of livestock, varieties of wheat, fertilizers and ways of preventing and repairing damage from injurious insects and plant diseases.

The five farms (known as experimental farms) developed rapidly, as did federal agriculture capacity, which eventually expanded to include research establishments and farms in all provinces from coast to coast, including Newfoundland after it joined Confederation in 1949. They continued to be known as experimental farms until 1914, when the official name of the overarching organization was changed to the Experimental Farms and Stations. In the same year, the Entomological Branch was established by grouping the Department's entomologists in one unit.

Other reorganizations occurred in subsequent years: in 1937, Experimental Farms and Stations became Experimental Farms Service, and the Entomological Branch was renamed Science Service. In 1959, a major reorganization led to the establishment of Research Branch. This new entity brought together Experimental Farms Service and Science Service under an Assistant Deputy Minister, Research.

The number of research facilities had grown significantly since 1886. By 1993, in addition to the Central Experimental Farm, 38 farm stations and their affiliated establishments were established by the Governor in Council under the recommendation of the Minister of Agriculture and pursuant to the *Experimental Farm Stations Act*. Agricultural research undertaken by the federal government over the past century has had a profound effect upon the agricultural sector and made a major contribution to the success of Canadian agribusiness.

The Management of Research Branch from 1986 to 2011

Yvon Martel, Chief Scientist, International, Research Branch, Ottawa

At the beginning of the second century of federal agricultural research, Research Branch had 62 research sites, including research centres, research stations, experimental farms and a number of smaller units. With 900 researchers and 3,500 employees, the Branch was conducting half of Canada's total agricultural research. The other research organizations included universities, the provinces, the private sector and the National Research Council of Canada. If the first 100 years were marked by a continuous expansion of the research infrastructure and budget, the ensuing 25 years were characterized by the need to increase efficiency in order to maintain a productive science program for the benefit of the Canadian agri-food sector. During the 1990s, the private sector became increasingly involved in priority-setting and the financing of research. In 1995, the Agri-Food Research and Development Matching Investment Initiative (MII) was created through which the Department, producers and industry jointly funded hundreds of agricultural research projects. In the subsequent decade, the Branch realigned its research priorities with those of the Agricultural Policy Framework (2003-2008) and, later, Growing Forward (2008-2012).

A. Evolution of Research Branch

Federal agricultural research entered its second century with the same responsibility to maintain and improve the productivity of the agri-food sector through the development and transfer of new knowledge and technology as it had been set out in the *Experimental Farm Stations Act* of 1886, but with a very different agricultural sector and a different approach.

The years 1986 to 1994

In 1986, the federal and provincial ministers of agriculture approved a National Agriculture Strategy, which included a commitment to research and asserted that federal and provincial efforts in technology development and transfer should be increased and coordinated closely with stakeholders.

In 1987, a federal-provincial committee was appointed at the request of the Deputy Minister of Agriculture, Jean-Jacques Noreau, to develop a blueprint for future research and technology transfer. Between 1987 and 1991, nine working papers were published under the title, *Canadian Agricultural Research and Technology Transfer, Planning for the Future*. The Branch identified new initiatives to ensure the contribution of stakeholders to future research priorities and programs, including the creation of the Research Branch Advisory Committee, research station advisory committees and program/research station reviews.

In the late 1980s, discussions within the Department focused on whether research dollars ought to be invested in the private sector and the university sector rather than in-house. Meanwhile the cost of maintaining the Branch's infrastructure and science capacity was becoming a budgetary concern.

Canadian Agricultural Services Coordinating Committee

The Canadian Agricultural Services Coordinating Committee (CASCC) was created in 1932 to act as the national advisory body to the Department of Agriculture for the overall coordination of agriculture research and non-research priorities. Chaired by the Deputy Minister, it received annual recommendations from the provincial agricultural services coordination committees, comprised of key provincial, regional, federal and private sector representatives. Priorities supported by CASCC were submitted to the Department for implementation.

In 1994, CASCC was discontinued and the Canadian Agri-Food Research Council (CARC) assumed responsibility for coordinating agricultural research and development as well as technology transfer.

In 1991, Research Branch mandated the Canadian Agricultural Research Council to organize a national conference in Montreal entitled *Partnerships: A Focus on Technology*. The conference brought industry, university, and government representatives together to discuss research and technology transfer. It was concluded that the private sector needed to play a greater role in funding and directing research. Four major themes were identified for Research Branch's future direction:

- Building and maintaining competitiveness;
- Improving communication for better technology transfer;
- Accelerating the regulatory response; and
- Strengthening partnerships with industry to ensure a connection between research and market needs.

Following the conference, the Branch wrote its 1993-1994 business plan, defining its mission as to "improve the long term competitiveness of the Canadian food and agriculture sector through the development and transfer of innovative knowledge and technologies." In the 1995-2000 business plan, the Branch mission was modified to "... improve the ongoing competitiveness..." in order to address producer and industry concern that without such ongoing support the agricultural sector would become less productive and possibly not survive.

Canadian Agri-Food Research Council

The Canadian Agricultural Research Council (original name) (CARC) was created in 1974 to report on the state and the needs of national agricultural research and development. Its membership included representatives from Agriculture and Agri-Food Canada (AAFC) and provincial governments, from universities of agricultural and veterinary medicine, from a number of national organizations (such as the Canada Grains Council, the Canadian Federation of Agriculture, the Canadian Forage Council, the Canadian Pork Council, the Agricultural Institute of Canada and the Canadian Horticultural Council), and chairs of four national "Canada committees" on crops, animals, natural resources and food. CARC began to receive funding from AAFC in 1992 and established a small full-time staff in Ottawa. It updated the National Strategy for Agri-Food Research and Technology Transfer every five years, helped industry develop sector-based strategies and managed the national database for agri-food research in Canada, known as the Inventory of Canadian Agri-Food Research.

By the mid-2000s, the Department, universities and provincial partners were questioning the continued need for CARC. A review was conducted and CARC was disbanded in 2007.

Agri-Food and Food Science

While food research was already being conducted at centres such as in Ottawa, Ontario, Lacombe, Alberta and Kentville, Nova Scotia; the completion, in 1986, of a research building in Summerland, British Columbia with a food processing pilot plant, and the formal opening of a completely new food research centre at Saint-Hyacinthe, Quebec in 1987 expanded the capacity of food science in Research Branch.

In 1997, food research program conducted at the Central Experimental Farm in Ottawa was transferred to Guelph, Ontario with new facilities being built and formally opened in 2000. It became Research Branch's 19th research centre.

In 1993, the research establishments were consolidated into 24 research centres. Ten were located in the Eastern Region, eleven in the Western Region and three in the Ottawa Central Region. Each centre was given a mandate to carry out research of national importance in its geographic area. To deliver on the Research Branch objective, the Branch has four principal areas of business and 17 research programs:

- **Resources:** land, germplasm/pests and biological control;
- **Crops:** cereals, oilseeds, forages, field crops, vegetable, tree fruits and berries, and ornamentals;
- **Animals:** beef, dairy, swine, poultry and other animals; and
- **Food:** animal products and processes, crop products and processes, and non-food products and processes.

The years 1995 to 1999

In 1994, the federal government had undertaken a major program review across departments "to ensure that the government's diminished resources were directed to the highest priority requirements and to those areas where the federal government was best positioned to deliver services." Government programs and activities were reviewed using six criteria: whether the public interest would be served; whether government involvement was necessary; whether an appropriate federal role could be articulated; whether scope for public sector/private sector partnerships was foreseen; whether scope for increased efficiency was foreseen; and affordability.

The results of this review were announced in the 1995 federal budget. Minister of Agriculture Ralph Goodale released a document entitled *Securing our Future in Agriculture and Agri-Food*, which explained the changes announced in the budget and their impact on the Department.

As a result of the 1995 budget the Agri-Food R&D Matching Investment Initiative (MII) was created to better support industry-involvement in research and development. Through this initiative, the Department matched private sector investment in joint research projects for a projected total investment of $70 million annually by 2000 ($35 million from the Department and $35 million from industry). Priorities for this program were determined by industry to help ensure the relevance of the research and to facilitate technology transfer. The MII was rapidly taken up by producer organizations and the agri-food industry. By the end of the decade, the number of projects exceeded 900, with a total value of $60 million.

Echo News

Dr. Tom Anstey, author of *One Hundred Harvests*, the centennial-year history of Research Branch, established a newsletter for retired managers of Research Branch in 1986. First known as the *Newsletter of Retired Officers-in-Charge*, it later became the *Echo News*. The newsletter was defined as being about the life of retired people, and provided information on Research Branch. It was published up to twice a year. Dr. Anstey was assisted first by Dr. Tibor Rajathy and later by Dr. Ed Lister, who eventually took full responsibility for the newsletter. Dr. Anstey remained Editor Emeritus until his death in 2005.

In November 2010, the paper newsletter was overtaken by the electronic age; Dr. Art Olson, former Assistant Deputy Minister, Research, assisted by Gilles Rousselle, helped set up a private blog for continuing communication among the retired managers of Research Branch.

On the other hand, savings had to be found, through reductions in areas in which research results were portable or location independent (research undertaken in one part of the world that could be readily adaptable and applied to Canada), and secondly, through a reduction in infrastructure costs. Research Branch moved toward a more cost-effective national network of 19 research centres of excellence, each with a specific national mandate; and seven research establishments located at La Pocatière, L'Assomption, Thunder Bay, Smithfield, Regina, Vegreville and Prince George were identified for closure.

The phasing out of Research Branch programs and physical sites opened the door to new initiatives involving local organizations and communities. For example, La Pocatière's Research Farm was transferred to the not-for-profit *Centre de développement bioalimentaire du Québec*, which in turn transferred its sheep flock and sheep barn complex to the new not-for-profit *Centre d'expertise en production ovine du Québec*. Similarly, the Research Farm at L'Assomption was transferred to the City of L'Assomption and later to the City of Montreal to serve as its nursery site, while the research laboratory building continued to serve as an incubator for technology development. In New Brunswick, south of Fredericton, the Atlantic Dairy and Forage Institute was created. It acquired the animals and equipment of the dairy program formerly conducted at the Fredericton Research Centre, and focused its activities on the need of dairy producers for high-quality forages.

Specifically affected by the 1994 Program Review was the National Capital Region, where the Centre for Food and Animal Research, located both on the Central Experimental Farm and at a site in the Greenbelt of southwest Ottawa, was closed. In 1997, the Centre's food research component was moved to Guelph and the animal research component was phased out or transferred to other research centres. The Greenbelt site was transferred to the National Capital Commission and the animals and equipment sold or transferred to other sites. Two centres located on the Central Experimental Farm—the Plant Research Centre and the Centre for Land and Biological Resources Research—were amalgamated in 1997 and renamed the Eastern Cereal and Oilseed Research Centre (ECORC).

During the same period, in 1996, the Vancouver Research Centre, known for its plant virus research, was closed, and employees were transferred to other centres, including the Pacific Agri-Food Research Centre in Summerland. At several other research centres and research farms, budgets, programs and employees were reduced to meet the 1994 Program Review recommendations.

Names of Research Establishments

Originally, the *Experimental Farm Stations Act* of 1886 established five farm stations, including a central farm station in Ottawa. The farm stations were known as experimental farms. The number of research sites and establishments increased significantly and various names were used, including *experimental farms, experimental stations, sub-stations,* and *laboratories,* usually preceded by the term Dominion.

In 1959, the creation of Research Branch introduced the names *research stations* and *research institutes*. In 1986, the existing research institutes were renamed *research centres* and in 1993, the research stations were renamed *research centres*.

Research Branch used the term *research centre* in 1987 to name the new research establishment at Saint-Hyacinthe, and the term *research and development centre* in 1989. In Quebec, the other research stations were also renamed *research and development centres* in 1993.

Since 1993, the main sites have been known as *research centres* (*research and development centres* in Quebec) while their affiliated establishments are generally known as *research farms*.

Between 1995 and 1997, some 900 of the 3,200 positions in Research Branch were phased out. Overall, the private investment that occurred under MII compensated for the program reduction that occurred after the 1994 Program Review.

By 1997, Research Branch had 18 research centres, located in St. John's, Charlottetown, Kentville, Fredericton, Sainte-Foy (Quebec), Lennoxville, (Sherbrooke), Saint-Hyacinthe, Saint-Jean-sur-Richelieu, Ottawa, London, Harrow, Winnipeg, Brandon, Saskatoon, Swift Current, Lacombe, Lethbridge, and Summerland/Agassiz. In 2000, a 19th centre was added with the creation of the Guelph Food Research Program. Each has a specialized national mandate focusing on the particular strengths of the regional agriculture and agri-food sector.

Tetrapartite

In the 1970s, informal management meetings were taking place between Research Branch and the Agricultural Research Service (ARS) of the United States Department of Agriculture (USDA), France's Institut National de la Recherche Agronomique (INRA), and national research organizations in the United Kingdom (U.K.)

In 1980, ARS, INRA and Research Branch representatives proposed a more structured meeting mechanism that would include the participation of the U.K. (Department for Environment, Food and Rural Affairs, the Biotechnology and Biological Sciences Research Council and Scotland's Rural Affairs and Environment Directorate). The first meeting was hosted by INRA in 1983 in Paris and has been followed by annual meetings known as the "Tetrapartite" meetings, which are held in each country on a rotational basis. Canada hosted its first meeting in Ottawa in 1986 in conjunction with Research Branch's centennial. Subsequent meetings in Canada occurred in Quebec City in 1990 and 1998, in Summerland and Vancouver in 1994, in London in 2002, in Lakeside, Prince Edward Island in 2006, and in Montreal in 2010. The meetings provide an opportunity for senior managers to share their experience in science management and to foster collaboration in research.

Dr. Edward Knipling, ARS Administrator, participated in the first Tetrapartite meeting in 1983 and through his leadership contributed greatly to the long-term success of these meetings. On the occasion of the Branch's 125th anniversary, he extended "...special congratulations to Agriculture and Agri-Food Canada and thanks for the many professional partnerships and friendships with ARS that have accrued through the Tetrapartite meetings and other means."

Changes during the 1980s and 1990s in regulations for managing financial resources added flexibility to the management of research centres. These included:

- The re-investment into research of the revenue from the sale of animals and crops, and the licensing of Crown-owned intellectual property, royalties and other assets that had previously been returned to the Government's general funds; and
- The re-investment of user fees in areas that did not compete with the private sector. User fees were collected at the Saint-Hyacinthe Food Research and Development Centre whenever industry used the expertise, equipment and facilities to carry out research and development.

The years 2000 to 2004

In the spring of 2000, a new Deputy Minister, Samy Watson, was appointed. Under his leadership, a new vision for the Department was adopted that focused on more integrated organization. In the 2001 Speech from the Throne the federal government announced its commitment to "...help Canada's agricultural sector move beyond crisis management, leading to more genuine diversification and value-added growth, new investments and employment, better land use, and high standards of environmental stewardship and food safety."

Subsequently, the federal, provincial and territorial ministers of agriculture endorsed a five-year (2003-2008) Agricultural Policy Framework (APF) that emphasized five priority areas: food safety and quality; the environment; renewal; science and innovation; and business risk management. To realign its research programs with departmental APF priorities, Research Branch regrouped its activities and priorities under four national research programs: environmental health; sustainable production systems; food safety and quality; and bioproducts and bioprocesses.

In 2003, Research Branch created an external advisory panel to review the realignment of the Branch's science with the APF. Chaired by Dr. Larry Milligan, former Vice-President of Research at the University of

Guelph, the panel concluded that the national science programs supported APF priorities and the role of the government in science. The panel also recommended a review of the Branch's science priorities, infrastructure, human resources and communication strategy.

The Minor Use Pesticide Program

The Minor Use Pesticides Program was launched in June 2002 as a joint initiative of Agriculture and Agri-Food Canada (AAFC) and Health Canada's Pest Management Regulatory Agency (PMRA). In 2003, the Pest Management Centre (PMC) was established by AAFC. PMC delivers the Minor Use Pesticides Program, which responds to the need of Canadian growers for new minor uses of pesticides, and the Pesticide Risk Reduction Program, which focuses on delivering reduced-risk pest management solutions, including biological controls and integrated approaches, for both major and minor crops.

The PMC operates from its headquarters in Ottawa and at nine regional Research Branch sites (Bouctouche, New Brunswick; Kentville, Nova Scotia; Saint-Jean-sur-Richelieu, Quebec; Vineland, Delhi and Harrow, Ontario; Scott, Saskatchewan; Summerland and Agassiz, British Columbia). It receives advice from advisory and technical committees consisting of members from the grower community, industry, government, research, and environmental groups.

These recommendations provided the foundation for developing a science management strategy. In 2003, Research Branch established the Office of Intellectual Property and Commercialization (OIPC). OIPC manages the commercialization of the Department's innovations through the private sector, with an office in Ottawa and staff working at the research centres. OIPC receives and manages invention disclosures, develops and implements intellectual property protection strategies, markets technologies, and drafts agreements with external parties and other government departments. Since 2003, OIPC has negotiated and signed more than 6,000 agreements with more than 1,500 national and international collaborators.

The same year, Research Branch also established the International Scientific Cooperation Bureau (ISCB). With more than 90 percent of agricultural research conducted outside of Canada, it was necessary to develop the international scientific cooperation in order to share excellence in agriculture science and to access the world scientific knowledge for the benefit of Canadian producers and industries. A strategy was built on four pillars: leveraging the Department's science capacity, enhancing international trade opportunities, ensuring Canadian participation in key multilateral forums, and providing expertise in support of global food security. In 2011, the ISCB had managed 54 collaborative scientific arrangements with 22 countries. Discussions with the European Commission on the Seventh Framework Programme have resulted in a new initiative called "the twinning concept" of research projects for facilitating the international cooperation between institutions. In complementarity, more than 150 Ph.D. students supported by foreign governments and universities have come to AAFC to complete their research requirements, China being the main participant.

The years 2005 to 2007

In February 2005, following a federal government review of departmental spending and activities to achieve more efficiency, the government announced that the Department's scientific research would continue at current funding levels but would be better consolidated, which meant closing the research establishments in St. John's, Newfoundland; Nappan, Nova Scotia; Kapuskasing, Ontario; and Winnipeg, Manitoba. In June 2005, the Minister announced that the closures were on hold and that the Department would conduct a comprehensive national consultation based on five core principles: investment would be maintained at current levels or higher; activities in all provinces would be maintained generally at current levels; science would meet the needs of the agriculture and agri-food industry; science would take into account regional differences; and science initiatives would be integrated with the planning and delivery strategies of other government partners, universities and industries in Canada and abroad. The results of the regional and national consultations served as a basis for developing the new Science Strategy.

Agriculture Minister Chuck Strahl formally announced the Department's new Science and Innovation (S&I) Strategy in Montreal in May 2006. The Strategy articulated a leadership role for Research Branch in the development of a national science and innovation capacity for the agriculture and agri-food sector, with a focus on strategic partnership with the private sector. The core of the S&I Strategy consisted of seven research priorities through which science and innovation could contribute to the development of the agriculture and agri-food sector in Canada:

- Enhance human health and wellness through food, nutrition and innovative products;
- Enhance food quality and the safety of the food system;
- Enhance the security and protection of the food supply;
- Enhance economic benefits for all stakeholders;
- Enhance the environmental performance of the Canadian agricultural system;
- Enhance understanding of Canadian bioresources, and protect and conserve their genetic diversity; and
- Develop new opportunities for agriculture from bioresources.

The same year, the Agricultural Bioproducts Innovation Program (ABIP) was created with the objective of mobilizing and integrating Canada's creative talent in the academic, private and public sectors into research networks and clusters to further develop agricultural bioproducts in Canada. The program funding offered flexibility for both internal and external science collaboration and pioneered an effective approach to science collaboration among government departments, universities and private companies. ABIP was in place until 2011.

To ensure excellence in research, the Branch announced in August 2006 the implementation of an external peer review process involving qualified and experienced Canadian and international scientists. The peer review panels assessed research proposals for their scientific merit, while departmental management verified the alignment of research proposals with departmental and Research Branch priorities before final approval by Research Branch Executive Committee.

The years 2008 to 2011

In July 2008, in Quebec City, Canada's federal, provincial and territorial ministers of agriculture endorsed the Growing Forward Agricultural Policy Framework (2008-2012). Growing Forward emphasized the importance of both innovation and science to a profitable and innovative agriculture, agri-food and agri-based products industry. This new vision marked a milestone in cooperation with the private sector, by establishing four initiatives to be implemented by the Branch:

- **The Canadian Agri-Science Clusters Initiative.** The Department provided funding and asked industry to contribute financially and to take the lead in identifying and carrying out priority research in the sector. Ten science clusters were created.

1. Beef Cattle Industry Science, led by the Canadian Cattlemen's Association.
2. Dairy Innovation: Nutrition/Health and Sustainable Development, led by the Dairy Farmers of Canada.
3. Canadian Swine Research and Development, led by the Canadian Swine Research and Development Cluster Inc.
4. Canadian Poultry Science for Sustaining Industry Competitiveness and Addressing Societal Issues, led by the Canadian Poultry Research Council.
5. Canola/Flax Agri-Science, led by the Canola Council of Canada.
6. Pulse Science, led by the Pulse Crops (Canada) Association.
7. Canadian Wheat Breeding Research, led by the Western Grains Research Foundation.
8. Canadian Agri-Science for Horticulture, led by the Canadian Horticultural Council.

9. Canadian Ornamental Horticulture Research and Innovation, led by the Vineland Research and Innovations Centre Inc.
10. Improving the Competitiveness and Profitability of Canadian Agriculture with Organic Science, administered by the Organic Agriculture Centre of Canada, Nova Scotia Agricultural College.

- **The Developing Innovative Agri-Products Initiative** facilitated the development of joint projects between the Department and the private sector. The initiative supported industry-led projects that bridge the gap between ideas/discoveries and products in the marketplace. Both industry and the Department contributed to funding 41 projects involving diverse industry partners and touching on nearly all parts of the agriculture, agri-food and agri-products sector.
- **The Agri-Foresight Initiative** was established to explore and anticipate, with various stakeholders, the opportunities and challenges for the sector in light of climate change and the growing bio-economy.
- **The Promotion of Agri-based Investment Opportunities Initiative** brought together potential investors and entrepreneurs within the agriculture, agri-food and agri-based products sector through a series of national symposia and events to help entrepreneurs attract equity capital for agri-based business ventures.

B. Governance of Research Branch

This section presents the evolution in the governance of Research Branch for the period of 1986 to 2011. It is marked by numerous organizational changes. In complementarity, the appendix at the end of the book presents organization charts and a list of ministers and managers who have been leading the Department, Research Branch and the Research Centres over the past 25 years.

The years 1986 to 1990

Research Branch began its second century in 1986 with a decentralized governance structure, consisting of the Assistant Deputy Minister (ADM), Research, Dr. Edward J. LeRoux, assisted by a special advisor, Dr. Ronald L. Halstead, who served as acting ADM at times, and directors general located in five regions: Dr. Yvon Martel, Atlantic Region (Halifax), Mr. Jean-Jacques Jasmin, Quebec Region (Montreal), Dr. Jean-Jacques Cartier, Ontario Region and Central Experimental Farm (Ottawa), Dr. William L. Pelton, Prairies Region (Regina), and Dr. Steve C. Thompson, Pacific Region (Vancouver). The Program Coordination Directorate, led by Dr. Wolfgang Baier, as acting director general, was located in Ottawa.

Following the retirement of Dr. LeRoux in 1986, Dr. Ian de la Roche served as acting ADM, Research. He was followed in 1987 by Dr. Art Olson who had worked for the Alberta provincial government. Dr. Olson introduced a number of changes to the Branch, the first being a reduction of the number of regional directors general from six positions to three and their relocation to Headquarters in Ottawa in order to facilitate communication among departmental senior managers. The directors general were: for the Eastern Region, Dr. Yvon Martel; for the Western Region, Dr. William L. Pelton, followed by Dr. Gordon Dorrell in 1989; and for the Central Region, Dr. Jean-Jacques Cartier, followed by Dr. Jean-Claude St-Pierre in 1988 and Dr. Gordon Dorrell, as acting, in 1995.

In 1987, the Program Coordination Directorate became the Priorities and Strategies Directorate under Dr. Ian de la Roche. In 1988, Dr. Olson reorganized the Directorate into two separate directorates. The first was the Research Coordination Directorate, responsible for coordinating science programs across the Branch under Dr. Carl Willis in 1988, Dr. G. Mac Weaver in 1992, and Dr. Jean-Claude St-Pierre in 1995. The second was the Strategies and Planning Directorate, responsible for managing the Branch's finance and management services, Research Program Services, the new Industry Relations Office, and the new Policy and Client Relations Division. It was led by Mr. Don F. Kirkland, Director General, followed by Ms. Janet F. Ferguson-Milne in 1990, and Mr. Peter Hall, acting, in 1995.

The years 1991 to 1999

In 1991, Dr. Olson accepted a position as head of Food Production and Inspection Branch, and Dr. Brian Morrissey became ADM, Research in 1992, having worked previously for Food Production and Inspection Branch as well as for the Department of Fisheries and Oceans. Dr. Morrissey promoted the consolidation of science and administration at a number of targeted research establishments in order to improve the efficiency of research delivery and to reduce the cost of management. From 1993, the term "research centre" was used throughout Canada for 24 major research establishments. As well, research centres started to use names based on their mandates rather than being identified by location.

Following the 1994 Program Review, Dr. Morrissey implemented new changes to further streamline operations and reduce expenditures. The two directorates at Headquarters were amalgamated and renamed the Research Planning and Coordination Directorate, which was subsequently led by Mr. Bruce Mitchell. The management of the Central Experimental Farm Region in Ottawa was added to the responsibilities of the director general of the Western Region in 1995 and subsequently transferred to the Eastern Region in 1997. As a result, the number of directors general was reduced—from five to three—to include the Eastern and Western Regions and Headquarters. Dr. Yvon Martel remained responsible for Eastern Region and Dr. Gordon Dorrell for Western Region. The titles of the two positions were later changed to Chief Scientist, Agri-Food, and Chief Scientist, Agriculture, respectively.

Use of Mandates in the Names of the Research Centres

In the Eastern Region:

- **St. John's** became the Atlantic Cool Climate Crop Research Centre;
- **Charlottetown**, the Crops and Livestock Research Centre;
- **Kentville**, the Atlantic Food and Horticulture Research Centre;
- **Fredericton**, the Potato Research Centre;
- **Sainte-Foy**, the Soils and Crops Research and Development Centre;
- **Lennoxville**, the Dairy and Swine Research and Development Centre;
- **Saint-Jean-sur-Richelieu**, the Horticulture Research and Development Centre;
- **London**, the Pest Management Research Centre and renamed in 1998 the Southern Crop Protection and Food Research Centre;
- **Harrow**, the Greenhouse and Processing Crops Research Centre.

Saint-Hyacinthe was already named after its mandate as the Food Research and Development Centre.

In the Western Region:

- **Winnipeg** became the Cereal Research Centre;
- **Swift Current**, the Semiarid Prairie Agricultural Research Centre;
- **Summerland** with **Agassiz**, the Pacific Agri-Food Research Centre (after 1996);
- **Vancouver** with **Agassiz**, the Pacific Agri-Food Research Centre (after 1996);
- **Beaverlodge**, the Northern Agriculture Research Centre;
- **Morden**, the Agri-Food Diversification Research Centre.

Lethbridge, Saskatoon, Lacombe and **Brandon** kept their original location names because of the diversity of their programs.

In the Central Region:

In **Ottawa**, the three existing research centres were already named after their mandates: the Centre for Food and Animal Research, the Centre for Land and Biological Resources Research, and the Plant Research Centre.

The years 2000 to 2005

In 2000, under incoming Deputy Minister, Samy Watson, the Department changed its governance structure to one that was team-based, with teams named "horizontal" and "enabling." Three horizontal teams were created to deliver the science programs: environment; food safety and quality; and innovation and renewal. Seven enabling teams were made responsible for departmental operations: human resources; finance; assets; management and information systems; policy and planning; communications and consultations; and program delivery. Employees associated with the enabling functions in Research Branch were consolidated into these new centralized enabling teams. The research component of Research Branch was allocated across the three horizontal teams as support for science delivery at the 19 research centres.

The First Woman Appointed Director of a Research Station

The year 1991 saw the appointment of the first woman as director of a Research Station. Angèle St-Yves was a graduate of Laval University in agricultural engineering. Her career included serving as Director of two of Agriculture and Agri-Food Canada's (AAFC) research centres—the Sainte-Foy Research Station and the Food Research and Development Centre at Saint-Hyacinthe—and later as National Program Leader, Food Safety and Quality.

Angèle St-Yves received numerous awards and inspired countless young women seeking careers in science at AAFC, mentoring and advising many of them with respect to training, work-life balance and equal opportunity.

Dr. Morrissey retired at the end of 2000 and Dr. Gordon Dorrell served as acting ADM, Research. The Branch began to realign its management in order to accommodate the new horizontal structure of the Department and the priorities of the Agriculture Policy Framework. In April 2002, the responsibilities of the two chief scientists (Agri-Food and Agriculture) were assumed by four National Program Leaders (NPLs), each responsible for a science program: environmental health; sustainable production systems;

food safety and quality; and bioproducts and bioprocesses. They were assisted by 19 national science theme leaders—formerly research centre directors—now responsible for the national coordination of science and scientific projects across the research centres.

During that period of transition, several managers served in an acting capacity. The first four acting NPLs were Dr. Jean-Marc Deschênes (environmental health), Dr. Steven Morgan Jones (sustainable production systems), Dr. Gordon Neish (bioproducts and bioprocesses) and Mrs. Angèle St-Yves (food safety and quality). The following year, with the retirements of Dr. Deschênes and Mrs. St-Yves, Dr. Wayne Lindwall acted as NPL for environmental health and Dr. David Bailey became acting NPL for food safety and quality. In addition, Dr. John Culley became the acting head of the newly created Office of Intellectual Property.

Conversions of Determinate Positions to Indeterminate Positions

In the late 1990s, some 80 percent of new federal public service recruits were appointed on a determinate basis, which led to the percentage of non-permanent employees in the Department reaching 29 percent in 2001. In Research Branch, these employees were highly qualified and important contributors to the success of research. They worked mainly on projects with sunset funding, such as the Agri-Food R&D Matching Investment Initiative, their contracts being renewed on a periodic basis. The Deputy Minister asked the Human Resources Branch to lead, with Research Branch, a committee of selected employees in a nation-wide consultation on the management of the increasing number of determinate employees in the Department. The committee submitted a report to the Department, which subsequently decided to convert determinate-status employees to indeterminate-status after two years of continuous service. The result was the conversion in 2003 and 2004 of several Research Branch employees from determinate status to indeterminate.

In April 2003, Dr. Bruce Archibald came to Research Branch to serve as ADM, Research as part of an exchange program with the Ontario Ministry of Agriculture, Food and Rural Affairs. He was subsequently appointed to the position. Among his first actions were the creation of the International Scientific Cooperation Bureau, and the appointment of Dr. Yvon Martel as Chief Scientist, International. He confirmed Dr. John Culley as Director, Office of Intellectual Property and Commercialization, and, in November 2003, appointed the four national program leaders as directors general: Dr. Wayne Lindwall (environmental health), Dr. Stephen Morgan Jones (sustainable production systems), Dr. Gordon Neish (bioproducts and bioprocesses) and Dr. David Bailey (food safety and quality).

In August 2004, 10 Science Directors were appointed, effectively replacing the national science theme leaders. Science Directors reported to four Directors General and were made responsible for the management of research scientists and national science across the research centres.

At headquarters, the Research Planning and Coordination Directorate was led by Mr. Bruce Mitchell until he retired in 2001. He was followed by Drs. John Culley and Gilles L. Rousselle, as acting. In May 2004, the Research Planning and Coordination Directorate became the Science Secretariat, with Dr. Christiane Deslauriers acting as Director General. In 2005, Dr. Gilles Saindon was appointed Director General of the Science Secretariat, which was renamed the Science Bureau.

In April 2005, Dr. Archibald returned to the Ontario Ministry of Agriculture, Food and Rural Affairs as Deputy Minister, and Dr. Yvon Martel served as acting ADM, Research. This period was characterized by a national consultation process conducted at the request of the Minister. More than 300 participants from Canadian producer organizations, processors, provincial and municipal governments, and other stakeholder groups were engaged in 11 regional consultation sessions during October and November 2005. These consultations culminated in the advent of the first National Agriculture Science and Innovation Symposium in November 2005, which was attended by 120 senior representatives from agriculture, agri-industry, universities, provincial governments, and other federal departments and agencies. The results of the consultations served as the basis for developing the new Research Branch Science Strategy.

The years 2006 to 2011

In January 2006, Deputy Minister Len Edwards announced that Dr. Marc Fortin would come to the Department on an Interchange Canada assignment from McGill University to be ADM, Research. Dr. Fortin was officially appointed in 2008. The arrival of the new ADM followed five years of transformation in the Department and the Branch. Upon his arrival, the new ADM undertook an outreach campaign, visiting the research centres and meeting employees in all provinces in an effort to gain hands-on knowledge and understanding of the challenges facing the Branch.

Designated Groups

At the end of the 1990s, several Research Branch employees were active in four departmental advisory committees representing each of the four designated employment equity groups: visible minorities, women, aboriginal people and persons with disabilities. Members of these four groups, along with their appointed management champions, met on a regular basis, held workshops and reported to the Departmental Management Committee annually. The objective was to ensure that members of the four designated groups were not only well represented in terms of numbers, but had a workplace that facilitated their participation in the delivery of services to Canadians.

In 2001, the Deputy Minister combined the four advisory committees into the 15-member Inclusiveness Management Committee. This committee includes representatives from the four designated groups and from the regions and various levels and branches. The committee has been involved in the revision of numerous policies, the development of the Department's Employment Equity and Inclusiveness Action Plans, and has made visits to numerous research centres to hear employee concerns about the challenges associated with inclusiveness.

In August 2008, Dr. Fortin announced a new governance structure for the Branch's management based on five functions:

- Science Partnerships Directorate, with Dr. Stephen Morgan Jones as Director General, to engage producer organizations and industry in the innovation sector. It became responsible for the Office of Intellectual Property and Commercialization, led by Dr. John Culley, and subsequently by Ms. Anita Ploj (in 2011);
- Innovation Program Directorate, with Mr. Clair Gartley as Director General, followed by Mr. Michael Whittaker in 2010, to develop and deliver the Growing Forward Innovation Program;
- Science Centres Directorate, with Dr. Gilles Saindon as Director General, to provide leadership, management and general directions to scientific research;
- Science Policy and Planning Directorate, with Dr. Christiane Deslauriers as Director General, responsible for strategy and policy development, the evaluation of results and the impact of science and innovation, as well as reporting and outreach functions; and
- International Scientific Cooperation Bureau, which would continue under Dr. Yvon Martel, Chief Scientist, International.

In addition, the Science Directors had three responsibilities: to oversee coordination of science under the seven research priorities; to manage national science themes across the research centres; and to be directly responsible for the research scientists of one or more research centres. The management of the daily operations of each research centre was assigned to Research Managers.

Dr. Fortin left the Department on March 15, 2011 to become CEO of the Defence Research and Development Corporation, and ADM, Science and Technology at the Department of National Defence. Ms. Jody Aylard of AAFC was appointed acting ADM, Research. At this time, the Growing Forward initiatives focusing on innovation were being implemented, and preparation was under way for the next agriculture policy framework, which would replace Growing Forward commencing in 2013-14.

Research Branch's 125th Anniversary

June 2, 2011 marked the 125th anniversary of the first five experimental farm stations created in 1886 by the Department of Agriculture. Using the theme *Rooted in Science - Innovating for the Future*, the Department commemorated the anniversary through a variety of initiatives, communications and promotional activities, including a web page, videos, exhibits and open houses, most of which were conducted during the summer and fall of 2011.

The commemoration of the 125th anniversary of Research Branch highlighted three major themes:

1. **Valuing our achievements:** Commemorating Research Branch's achievements over the past 25 years that benefited producers, industry and the Canadian economy. A total of 72 research highlights were presented in a poster that was distributed across Canada. An edition of Innovation Express published by Research Branch in the fall 2011 included a series of articles featuring major scientific accomplishments. Employees and managers used field days, speaking opportunities, and events to highlight the Department's longtime commitment as well as its achievements with respect to research.
2. **Valuing our employees:** Awarding the Research Branch 125th anniversary recognition tribute to our employees who have contributed to well-being in the workplace. Overall, 334 employees were given special recognition
3. **Valuing our history:** the preparation of this book, which focuses on Research Branch's history over the past 25 years. Seventy authors and many collaborators authored these articles on the history of each location of Research Branch.

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The Evolution of Research Information Services

Jean-Marc Deschênes, Director, (1998–2001), Research Branch, Ottawa

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Research Information Services, which was known as Scientific Information Services from 1959 to 1972, Research Program Services from 1973 to 1992, and Information and Planning Services from 1993 to 1997, played a key role in the technology transfer associated with the research findings made by Research Branch. The expertise in photography, graphic design, text editing, publishing, audiovisual services, exhibits and displays was of great assistance to scientists, making it possible to disseminate research results in layman's terms. In 1997, Information and Planning Services was discontinued and its responsibilities for information management, promotion and technology transfer were shared between Communications and Consultations Branch and Research Branch.

The early years, 1959–1985

In 1959, Research Branch established Scientific Information Services (SIS) to support research and development in the Branch as well as technology transfer and the diffusion of scientific knowledge. SIS maintained computerized scientific and technical information systems, provided publication, audiovisual, and art services, and administered the Branch's awards and international scientific exchange programs. In 1973, SIS was renamed Research Program Services (RPS) and continued to provide support to the Branch for the transfer of technologies and scientific information to stakeholders and the general public.

The beginning of the second century of research, 1986–1997

In 1987, Research Program Services (RPS) became accountable to the Priorities and Strategies Directorate of Research Branch instead of the ADM, Research, but continued to deliver the same services, administering operating grant and visiting fellowships programs, carrying out numerous graphic and audiovisual projects, and overseeing the printing of publications.

In 1988, RPS was organized into five sections with its director reporting to the newly created Strategies and Planning Directorate:

- Administration was responsible for the operating grants program, which provided grants to Canadian university scientists to carry out projects of value to the agricultural industry. It was also responsible for the visiting fellowships program, which gave young scientists in Canada and abroad the opportunity to work with Canadian scientists in their respective fields. The operating grants program became the Research Partnership Support Program co-funded by the Natural Sciences and Engineering Research Council, which matched funds committed by industry on a two-to-one basis;
- Editing and Publications (technology transfer) was responsible for the editing and publishing of departmental and Research Branch publications, technical bulletins, soil surveys and committee reports and books;
- Art and Design provided illustrations, photographs, publications, folders, exhibits and signs pertaining to the key activities and achievements of Research Branch;
- Audiovisual worked in collaboration with Art and Design; and
- Scientific Information and Retrieval administered the Inventory of Canadian Agri-Food Research and updated and maintained the Pesticide Research Information System.

RPS also supported Research Branch in organizing the activities of the Canadian Agricultural Services Coordinating Committee and the Canadian Agricultural Research Council. In 1989, Research Branch introduced the Study Data Base managed by RPS.

In 1990, after a review of its programs, RPS re-organized its activities into four sections:

- Technology Transfer encompassed the activities of the Art and Design and Audiovisual sections, the Editing and Publications section, as well as communications functions;
- Scientific Information administered the various databases;
- Research Coordination Support organized the activities of the Canadian Agricultural Services Coordinating Committee, Canadian Agricultural Research Council as well as fellowship programs; and
- Statistical Support provided statistical advice on experimental design as well as data management and analysis to scientists throughout Research Branch.

In 1991, RPS conducted a survey to determine the Branch's internal communications needs, created a bank of success stories and improved the delivery of key Branch messages in order to strengthen communications with research partners and internal and external audience. In 1992, RPS became responsible for the publication of *Canadex*. RPS also updated the Study Data Base to provide comprehensive information on the more than 1,000 studies then under way at the Branch. The information was also electronically provided to the Inventory of Canadian Agri-Food Research, which contains data on more than 4,000 agri-food projects. From 1987 to 1993, RPS had a staff of about 55 people.

In April 1993, Information and Planning Services (IPS) replaced RPS. IPS retained expertise in communications, publishing, research information management and strategic planning and in 1995-1996, became responsible for the management of many programs, databases, systems, publications and promotional activities, including:

- The Study Management System, which collected, tracked and updated Branch studies in order to facilitate their selection (this system replaced the Study Data Base);
- The Agriculture and Agri-Food Electronic Information System, which consisted of single-window Internet access to documents

such as AGvance (a newsletter promoting technology transfer and collaboration with industry), AgTran (a catalogue promoting technology opportunities in agri-food research), as well as the Inventory of Canadian Agri-Food Research and the Directory of Research;

- The Success Stories database, the cornerstone of Research Branch promotional activities;
- Communications. Research Branch successes were featured in departmental publications, exhibits, media tip sheets, and Minister's speeches;
- Visiting Fellowships and University Grants. Management support was provided to the Natural Sciences and Engineering Research Council, which sponsored these two programs; and
- Pest Management Information, which contributed to pest management information through Pest Management News, Canadian Plant Disease Survey and Pest Management Research Reports.

Key Achievements of Information and Planning Services

- Between 1987 and 1994, Information and Planning Services (IPS) issued more than 160 departmental publications and 250 Research Branch publications, including Tableau, Progress in Research, Research Branch reports and AGvance, technical bulletins, soil survey reports and expert committee reports, success stories and media tip sheets; it prepared numerous seminar and exhibit displays as well as scientific conference posters; and photographed a multitude of subjects both microscopic and macroscopic.
- In 1988, IPS arranged 58 visits of foreign scientists and 10 visits of Canadian scientists abroad, as well as 15 scientific missions of foreign delegations.
- Between 1995 and 1997, it developed and managed the Study Management System, the Agriculture and Agri-Food Electronic Information System, and Pest Management Information.

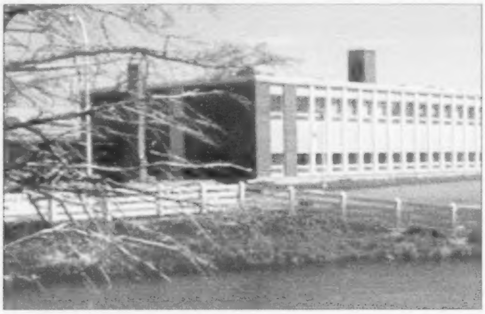
In 1997, IPS was discontinued, and its responsibilities were distributed to Communications and Consultations Branch and Research Branch. As well, certain publication and statistical services were transferred to Research Branch's regional offices to better meet the regions' publication needs.

Acknowledgements

Special thanks go to Peter Hall for his critical review of this section.

Chapter 2, Atlantic Canada

Atlantic Cool Climate Crop Research Centre
St. John's, Newfoundland and Labrador



Sandy Todd, Research Manager, Research Branch, St. John's
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Over the past 25 years, the Atlantic Cool Climate Crop Research Centre, formerly known as the St. John's Research Station, has made important contributions to the agriculture sector, helping industry maintain a competitive edge in cool summer production. Significant scientific progress has been made in plant breeding and propagation, integrated pest management, the improvement of forage and cereal crops, horticulture, nutrient management and agricultural water management. The Centre has links to the provincial agri-food sector, universities and industry associations, and is developing technologies that diversify and add value to rural economies in cool summer regions.

The early years, 1935–1985

In 1834, the Crown granted 162 hectares of land to Sir James Pearl, founding father of Mount Pearl, Newfoundland, in recognition of his naval and diplomatic services to Great Britain. Following Pearl's death in 1840, the estate was purchased by the Glendenning family. Half of the estate was sold to the Commission of Government of Newfoundland in 1935, which established and operated a demonstration farm and school on the site. The school offered a one-year, agrology-based course that focused on both academic and practical farm training. Herds of purebred Ayrshire cattle and Yorkshire pigs and a foundation flock of poultry provided stock for improving local herds and flocks. During this time, staff at the demonstration farm and at the federal Department of Agriculture's Experimental Farm in Nappan, Nova Scotia, jointly conducted several experiments focused on variety trials, insect control, fertilizer trials, and preservation techniques for silage.

When Newfoundland entered Confederation in 1949, the demonstration farm was acquired by the federal department. Only one research officer remained at the farm in 1950, but entomology and plant pathology labs were established on site in subsequent years, along with the facilities of the National Soil Survey. Expansion continued through the 1950s with the establishment of the Colinet peat research field site and the Avondale blueberry research field site, located 67 kilometres and 80 kilometres outside of St. John's, respectively.

The current research centre facility was constructed in the early 1960s. In 1981, the main building was extended to house the staff of the provincial Department of Agriculture, providing a great opportunity for federal and provincial agriculture researchers and experts to work closely on joint initiatives.

The beginning of the second century of research, 1986–2011

In 1986, the St. John's Research Station, as the demonstration farm was then known, consisted of a low-rise building containing offices and laboratories (agronomy, entomology, plant pathology and soils) with an attached greenhouse complex. The St. John's site (61 hectares) was the main location for field research activities, with work also being carried out at the two research field sites (Colinet (280 hectares) and Avondale (14 hectares)). The main research focus at the Centre was horticulture, with a secondary emphasis on animal feed crops. Horticultural research involved plant breeding, particularly of potatoes and rutabagas, plant pathology, including potato wart disease, insect pests, soil management, the development of peat soils for both forage and vegetable production, and the management of stands of native berries.

People and Programs: 1986

There were 35 employees on staff at the St. John's Research Station, including four scientists who carried out research in plant breeding, entomology, horticulture, plant pathology, agronomy and agricultural engineering.

Over the next several years, research evolved to meet the changing needs of the agricultural industry in Newfoundland and Labrador. After the Federal Government's 1994 Program Review, the potato breeding program moved from St. John's to the research centre in Fredericton and the plant pathology and rutabaga breeding programs were closed. In 1997, the name of the research station was changed to the Atlantic Cool Climate Crop Research Centre to reflect its research mandate. In 1998, the Colinet peat research field site was closed and its research staff moved to the Centre in St. John's.

Over time, the Centre's research focus slowly shifted toward an even division between animal feed and horticulture. Because of a limited arable land base, the province's dairy farmers rely on costly imported feed. Research to determine appropriate species and best management practices for livestock feeds in the province's unique soil and climatic conditions thus became an important part of the Centre's research.

Working with Industry

From 1994 to 2002, the Centre participated in a number of cost-shared programs with local industry under the Agri-Food R&D Matching Investment Initiative. Collaborative projects included the breeding of clubroot-resistant rutabaga, the development of a practical forage-production and harvesting system for peat soils, a project for pathotype differentiation of the causal agent of potato wart disease, the testing of biodegradable plastic mulches to accelerate corn growth, a project for ensuring efficient manure management to provide a nutrient source for feed crop production, the testing of precision farming models, and on-farm research on the cabbage maggot.

Throughout the first decade of the 2000s, research programs in St. John's remained focused on plant breeding and propagation, entomology and integrated pest management, forage and cereal research, horticulture crop physiology and management, nutrient and agricultural water management, water quality, and soil drainage for cool climates.

Farm Field Day

The Centre hosts one of the largest open-house events among all of the Department's research centres. Representatives from the agricultural industry and provincial government take part in the event to highlight and promote agriculture to the general public (5,000 to 10,000 visitors each year). Farm Field Day continues to be one of the premier agricultural events in the province.

In recent years, members of the Centre's research staff have cultivated feed and sweet corn, small fruits such as raspberries and blueberries, forage crops and horticultural crops such as cauliflower, rutabaga and lettuce. Field trials of innovative plasticulture technology, berry germplasm development, animal feed self-sufficiency, integrated pest management and manure management are an integral part of the Centre's research.

A tile-flow system capable of capturing year-round field drainage for water quality analysis was completed in 2008. In 2010, an experimental cranberry bog was constructed that will allow scientists to undertake new research in the enhancement of northern berry crops, cranberry in particular being an important crop in the province.

The Canadian Food Inspection Agency conducts research trials on potato varieties and potato wart and nematode resistance at the St. John's Centre and at Avondale, and operates a greenhouse. In addition, the provincial Forestry and Agrifoods Agency, the Newfoundland and Labrador Federation of Agriculture, and the Chicken Farmers of Newfoundland and Labrador are located on the Centre's grounds. In 2008, Environment Canada constructed a weather station at the Centre.

The Atlantic Cool Climate Crop Research Centre is a modern farm, laboratory, greenhouse and office complex, with 37 employees including five researchers. The Centre shares its facilities with the Department's regional office, Pest Management Centre and Agri-Environment Services Branch. The Centre is the lead agricultural research organization in the province and is recognized as a centre of excellence by the province's agricultural community for developing technologies that diversify and add value to rural economies in cool summer regions.

Research activities in St. John's have long been closely linked with those at other federal research centres, particularly in Atlantic Canada (Kentville, Nova Scotia; Fredericton, New Brunswick; and Charlottetown, Prince Edward Island) but also at Agassiz, British Columbia and Saskatoon, Saskatchewan. The Atlantic Cool Climate Crop Research Centre continues collaboration with the provinces and universities, particularly with Memorial University of Newfoundland in St. John's and the Nova Scotia Agricultural College in Truro. As well, Centre researchers continue to work closely with their counterparts at the provincial level and in industry on joint projects. They have also developed collaborations with international universities and research organizations.

Research highlights over the past 25 years

Horticulture

- Released potato cultivars resistant to potato wart disease and golden nematode. At one time 70 percent of potatoes grown in the province had their origins in this program
- Developed rutabaga cultivars resistant to clubroot and tolerant to cabbage maggot
- Researched the causal agent of potato wart disease, including biology, spread, persistence, monoxenic cultures under *in vitro* conditions and management
- Identified a gradient of emergence biotypes of the cabbage maggot, Delia radicum, across Newfoundland and; developed a relay cropping potential management tool for control of the pest
- Developed production protocols for vegetables on peat, including spacing, fertilizers and weed control
- Modified a commercial carrot harvester to improve performance on peat soils
- Revealed through long-term studies (more than 20 years) that nitrogen fertilization and weed control are key factors in increasing lowbush blueberry yields
- Held trials on many European lingonberry cultivars that led to recommendations of the best candidates of this unique northern berry crop for local conditions
- Developed and maintained the largest cool climate wild berry crop germplasm repository in North America
- Developed new techniques for small fruits and medicinal plant micro-propagation that enabled rapid field establishment, addressed increased demand for their production and gave new crop options to growers

- Characterized molecular and chemical (antioxidant) diversity in wild cranberry, lingonberry, cloudberry and lowbush blueberry, and in Canadian strawberry and raspberry
- Developed production protocols for Newfoundland roseroot, European lingonberry and Russian cultivars of sea buckthorn and honeysuckle, enabling new production systems for northern regions

Animal feed crops

- Carried out research in a cooperative forage evaluation program that led to the recommendation of cultivars suitable for local conditions
- Determined optimal production practices for cereal grain production in Newfoundland's unique climate, including seeding dates and rates, and nitrogen fertilization
- Determined that field peas have the greatest potential among the pulse crops for Newfoundland and Labrador
- Discovered that the implementation of short-season corn hybrids in conjunction with biodegradable plastic mulch led to unprecedented expansion of corn production, which in turn supported expansion of the dairy industry
- Developed production protocols for Newfoundland ecotypes of American dunegrass and beach pea for cool climate animal feed and forage
- Demonstrated that using modern subsurface drainage equipment and technology on mineral soils in forage production increased yields by 25 to 50 percent
- Modified existing equipment for round bale haylage, allowing harvesting on peat soils
- Designed a surface banding liquid manure applicator for research plot use, permitting accurate manure application

- Demonstrated that no-till seeding of old forage fields on the stony, rocky soils typical to eastern Newfoundland is a cost-efficient alternative to renovation using tillage
- Showed that red clover decline was due in large part to root-feeding weevils

The Atlantic Cool Climate Crop Research Centre, despite being the smallest of the Department's research centres, plays a vital role in the development of agriculture in one of Canada's most economically vibrant provinces.

The Centre is responsible for the development of agricultural technology supporting the growth of primary production in the boreal ecozone of Newfoundland and Labrador. Research is concentrated on primary production agriculture through agronomic support for horticultural crops, especially berries suitable for production in the boreal ecosystem, forage and cereal crops in support of the regional dairy value chain, and environmental stewardship through improved performance of the agricultural production system. The Centre collaborates with other northern centres and research farms, including those in Normandin, Quebec; Kapuskasing, Ontario; and Beaverlodge, Lacombe and Fort Vermilion in Alberta.

Acknowledgements

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Crops and Livestock Research Centre
Charlottetown, Prince Edward Island

Richard Martin, Research Scientist, Research Branch, Charlottetown

The Charlottetown Experimental Station was established in 1909 to support the development of mixed agriculture on Prince Edward Island. Over the years, research at the Centre has evolved to address problems and opportunities in field and horticultural crop production, pest management, animal husbandry, and nutrient and soil management. This research effort led to the release of cereal and forage cultivars with improved agronomic characteristics, disease resistance and quality, the assessment and introduction of new crops suited to the Atlantic region, the development and evaluation of intensive management systems for small grain cereals, improved production practices for potato, the development of weed, disease and insect control strategies, the development of soil and nutrient conservation practices, and improved animal nutrition strategies. The Centre serves both regional and national research needs by concentrating on pest management, soil and water management, development of sustainable production systems, and the search for new food-feed bioactive compounds that have health benefits.

The early years, 1909–1985

In the summer of 1909 the Charlottetown Experimental Station became the ninth federal agricultural research facility. Land in what is now central Charlottetown was initially purchased by the provincial government and leased to the Department of Agriculture. Over the years, the facility grew to its current size of 67 hectares of federally-owned land, known as the Home Farm. Initial work concentrated on the evaluation of cereal and forage crops to identify the cultivars best suited to P.E.I.'s soils and cool, moist climate.

Horticultural work began early on, with the planting of fruit trees and ornamental shrubs. Sheep, dairy and poultry evaluations also began at this time. In 1915, the Plant Pathology Laboratory (later called the Science Service Laboratory) was established on the Station to conduct research on plant diseases; in 1937, entomological research became part of the program in Charlottetown. The Science Service Laboratory provided much needed assistance to Island farmers by (among others) running a seed potato certification service that helped position the potato industry as a key influence on the Island landscape and economy.

From the early 1940s, the role of the Station expanded to include a soils program and an increased emphasis on dairy research. Cereal work was enhanced, with Charlottetown being given the responsibility for variety breeding and development for the Atlantic Region. By the early 1950s, a second, 100-hectare farm, the Upton Farm, was established just outside of Charlottetown. It became home to animal research and most of the field crop research. In 1966, the Experimental Station was renamed the Charlottetown Research Station.

The 1970s saw a major increase in science capacity with the construction of a new laboratory and office building, and an influx of researchers and support staff. What followed was increased research in cereal breeding and development, forage management and cultivar evaluations, horticulture, weed science, cereal pathology, and soil and nutrient management. To accommodate this extra activity, a third farm, the Harrington Farm, of approximately 90 hectares, was established in 1983. The Upton Farm continued to be the central farm for animal work and much of the forage and cereal breeding work, while the Harrington Farm became the primary farm for potato studies, soils-related research, and some forage and cereal research. The original Home Farm was still used for research and demonstration and was the location for laboratories, greenhouses and offices, and the majority of the field service operations.

The beginning of the second century of research, 1986–2011

By 1986, the mandate of the Charlottetown Research Station included research on potatoes, cereals, forages, horticultural crops, pest management, nutrient management, soil stability, manure management, and dairy, beef, and swine nutrition research. At the same time, scientists continued to look to the future with research into new crops, such as soybeans, and production technologies that could have significant impact on the environmental and economic sustainability of agricultural production in Atlantic Canada and beyond.

People and Programs: 1986

The Station had 85 employees including 24 researchers working on the Home Farm and at the Upton and Harrington research farms.

The Harrington Experimental Farm was a major addition to the Station but was not sufficient to meet all needs, due partly to the expansion of research in areas such as soil and water quality and of nutrient management projects that required larger plots than had been used in the past. Greater control of the rotational aspects of farm management lengthened the time between research trials and experiments. In addition, increased pressure on field availability occurred with the establishment of long-term experiments, improved field and plot equipment, greater computer use, and additional projects and staff funded by farm organizations and industry partners. These factors triggered a move to increase the land base of the Harrington Experimental Farm. Through a combination of the purchase and leasing of adjacent properties, the site was increased to 330 hectares by 1990.

The early 1990s saw the staff consolidating field research at Harrington to increase the efficiency of the Station's overall operations. After the 1994 Program Review, some scientific programs were cancelled, notably the dairy/beef and micronutrient research programs. As well, the soil and potato management programs were reduced in order to utilize the remaining resources in a more focused way. Program changes accelerated the consolidation of research at the Harrington Experimental Farm, allowing the majority of the field research to be conducted at Harrington, with limited work being done on the Home Farm research field site. The Upton Farm research site was then closed.

From 1997 through to 2007, the Nappan Research Farm reported to Charlottetown. In 1997, Charlottetown underwent a name change to reflect its mandate, becoming the Crops and Livestock Research Centre.

People and Programs: 2011

The Crops and Livestock Research Centre has 60 employees working at the Home Farm and at the Harrington Experimental Farm located 11 kilometres north of Charlottetown, including 11 researchers carrying out research in the areas of soils and water, agronomy and pest management.

Three of the Centre's researchers are located at the Institute for Nutrisciences and Health, where they are expanding the research capability into molecular biology and natural products chemistry as part of the Centre's collaboration with the National Research Council and the University of Prince Edward Island.

In the 1990s, plans for improving infrastructure at Harrington included construction of new buildings to house support staff, general work areas, climate-controlled potato storage, equipment storage, maintenance facilities and other related facilities. These improvements culminated in a multi-million-dollar construction project in 2002. Many of the older and unsafe structures on the Home Farm research field site were subsequently dismantled, and the work was moved to new state-of-the-art facilities.

In 2001, ownership of the Upton Farm was transferred to Canada Lands Company and then to the province, where it was earmarked for development including a community parkland, a seniors' complex, and a biotechnology research and development park.

Since the early 2000s, priorities have shifted at the Centre as Research Branch and the Department moved in new directions under the Agricultural Policy Framework, and more recently, Growing Forward. The Centre's research focused on environmental sustainability, diversification and profitable agriculture, and innovation in primary production agriculture. It supports national research in integrated crop protection for key potato and cereal diseases and serves as a keystone for a knowledge-based agriculture. In 2003, it also fostered collaboration with the University of Prince Edward Island and the National Research Council with the creation of an Institute for Nutrisciences and Health.

New greenhouse and plant growth facilities were completed at the Harrington site in 2011, replacing half-century-old greenhouses on the Home Farm. These modern facilities will enable scientific staff not only to continue some of the current research and development projects in a more efficient setting, but also to move into new areas of research and development, such as bioactive compound identification and production in agricultural crops.

Research highlights over the past 25 years

- Released more than a dozen new barley cultivars, four superior winter wheat lines, and 10 spring wheat lines that showed improved yield and disease resistance and contributed to the economic sustainability of producers in Atlantic Canada and beyond
- Developed red clover cultivars with superior winter hardiness and forage yield
- Served as a key test site for the evaluation of traditional forage cultivars for the region, including cultivars of alfalfa, clover, ryegrass and timothy, and newer introductions, such as Kentucky bluegrass, fescue and chicory, which have been popular in the dairy industry
- Developed a testing protocol and computerized selection system for assessment and introduction of both silage and grain corn hybrids suitable for Atlantic Canada production

- In concert with the soybean breeder at the Eastern Cereal and Oilseed Research Centre (ECORC-Ottawa) and with the private sector, developed and evaluated testing protocols and new cultivars suitable for production in the Atlantic region's shorter season. This has led to the emergence of soybeans as a major crop in the region—both animal-feed and food-grade varieties. The food-grade beans are now being exported
- Carried out extensive evaluations of potatoes and other horticultural crops to refine cultivar-specific management protocols, to assess production characteristics of various horticultural crops—including potatoes—for yield and quality for both fresh- and processing markets, and to determine the disease resistance characteristics of new lines of potatoes
- Developed effective weed, insect, nematode, and disease control strategies aimed at decreasing losses associated with major pests, and at increasing economic and environmental sustainability
- Contributed to a better understanding of the agronomic production factors necessary to produce not only a high yield for small-grain cereals but to maintain a high milling quality
- Linked the fisheries and agricultural industries of the region in the development of composting methods for fin and shellfish waste, allowing for diversion of waste from dump sites and providing a local fertilizer source for crops
- Developed soil conservation techniques to reduce soil loss and stream siltation; developed management strategies to limit nitrate loss based on increased understanding of the behaviour of nitrates in soil and the water system
- Formulated recommendations on the timing of tillage and the type of tillage to maximize productivity while maintaining soil health and reducing erosion risks
- Improved nutrition of bulls, thereby reducing feed costs, and improved beef cow productivity through protein supplementation

- Co-developed computer models to estimate the growth-response of pigs under various disease and nutritional scenarios
- Developed a carrot trimmer that, by opening the canopy, changes the micro-environment and results in decreased incidence of sclerotinia rot; this equipment and technique is now being used worldwide
- Determined that crushing stems during potato harvesting reduces the survival of a major regional pest—the European corn borer—in an environmentally sustainable way

The Crops and Livestock Research Centre in P.E.I. serves regional and national agricultural needs, with emphasis on:

- Enhancing human health and wellness through food, nutrition and innovative products
- The security and protection of the food supply (by concentrating on major pathogens such as Fusarium head blight in cereals, late blight in potatoes, and insect pests such as the European corn borer and wireworm in potatoes)
- The economic benefits for all stakeholders through the development of sustainable production systems in cereals and oilseeds, horticultural crops and potatoes, and
- Nutrient management, soil erosion, and the protection of water resources from agricultural practices

With a view to possible new production in Atlantic Canada, the Centre is also looking into new oilseed crops and other potential crops for their industrial, food and feed, and bioactive potential.

Atlantic Food and Horticulture Research Centre
Kentville, Nova Scotia

Charles F. Forney, Research Scientist, Research Branch, Kentville
D. Mark Hodges, Research Manager, Research Branch, Kentville

The Atlantic Food and Horticulture Research Centre, formerly known as the Kentville Experimental Station, has a century-long history of conducting research in support of the agricultural industry in Atlantic Canada. For the first 75 years, the emphasis was on fruit and vegetable production, storage and processing, and on ornamentals and poultry research. The past 25 years have been particularly dynamic, with the introduction of more advanced technologies and growth in the understanding of the health potential of foods. Research is focused on the production of integrated pest management strategies for berry crops and tree fruits, the bioactive value of horticultural crops, the quality and safety of fruits and vegetables, and environment stewardship and best agricultural practices for fruits and vegetables. The Centre continues to conduct research of many kinds, from production through storage and transportation to food processing, with emphasis on safety, quality and environmental stewardship, in order to serve the needs of the agri-food industry and to contribute to the economy of Atlantic Canada.

The early years, 1911–1985

The Kentville Experimental Station was established in 1911 through the efforts of the Nova Scotia Fruit Growers' Association. The Station originally occupied 101 hectares, but was expanded over the years to its current size of 187 hectares. The primary focus of the Station was the resolution of horticultural problems, particularly those of the apple industry, although it also conducted a broadly based program of experimentation and demonstration in support of horticulture, general agriculture, home gardening and rural beautification.

Prior to the 1940s, numerous research programs at the Station were expanded. For example, extensive variety trials of fruits and vegetables were conducted to identify the most productive cultivars for Nova Scotia producers. A program in apple breeding focused on the development of disease-resistant trees, with primary emphasis on apple scab. Pioneering studies improved the productivity of the native lowbush blueberry and enabled the commercialization of the highbush blueberry in Nova Scotia. Entomologists and plant pathologists developed the concept of integrated pest management as an alternative to chemical pest control. Controlled-atmosphere storage technologies were developed, extending the storage-life of apples to nine months or longer. Food processing researchers developed a forced-air dehydrator that revolutionized fruit and vegetable dehydration and remained the dominant dehydration technology into the 1960s.

After the Second World War, the apple industry lost most of its export market to Britain, resulting in a surplus of apples and downsizing of the industry. Increased diversification of agriculture in Nova Scotia soon followed, with programs in fruit and vegetable production, storage and processing, in ornamentals, and in poultry being expanded and diversified.

The Kentville Experimental Station was renamed the Kentville Research Station in 1959, and Atlantic-region poultry research was amalgamated there in the 1960s. Two new poultry houses were constructed in 1967, and a new office and laboratory complex, where the Centre is presently located, was completed in 1981.

People and Programs: 1986

32 researchers worked at the Kentville Station:

- Crop production: 10
- Crop protection: 12
- Food-processing engineering: 6
- Fruit and vegetable storage: 2
- Poultry: 2

The beginning of the second century of research, 1986–2011

In 1986, the Station had five research programs: crop production (fruits, vegetables, and ornamentals); crop protection (harmful insects, diseases, and weeds); food processing (processing technologies and flavour analysis); fruit and vegetable storage (atmosphere and temperature management, fruit coating, and post-harvest disorders); and poultry (chicken, turkey meat, and egg production). Research under these programs continued through the 1990s.

Intensive research into wild lowbush blueberry was conducted between 1985 and 1995 and was instrumental in the expansion of the wild blueberry industry. Research on patterns for herbicides that provided superior control of grass, broadleaf and woody perennial weeds in the fields were developed, the effects of fertilizer on yield and vegetative growth were defined, and management techniques that improved productivity were studied.

Research began on the health-promoting properties of blueberries in the 1990s, based on the hypothesis that the health-protective effects of fruits and vegetables, including blueberries, stemmed from their containing abundant phytochemicals with antioxidant properties. Kentville's food chemistry team showed that consumption of blueberries significantly lowered plasma cholesterol in pigs and improved aspects of night vision in humans. The research also showed that blueberry compounds were retained in various regions of the brain and in the eyes.

Technologies in support of the greenhouse floriculture and nursery industries were developed until the early 1990s, using supplemental lighting to improve production of cut flowers and ornamental potted plants, and optimized lighting for the production of chrysanthemum and other commercial floricultural crops. Techniques were also developed to improve production of ornamental nursery crops with less fertilizer and water, by using sub-irrigation technology in combination with controlled-release fertilization.

Cultivar evaluation of grapes has supported the growing estate winery industry in Nova Scotia, with the 1981 recommendation of L'Acadie as a highly suitable grape for Nova Scotia's climate. L'Acadie has become the leading white wine grape variety grown in Nova Scotia.

Although active tree-fruit breeding at the Station ended in 1978, a number of selections have continued to be evaluated. Five apple and two pear selections have been granted Plant Breeder Rights status since 1995. Some of these selections have unique disease-resistant qualities that would support commercial organic production.

Research Partners

Centre researchers are linked with Canadian and international colleagues in a range of disciplines:

- Tree fruit genetic and physiology research (U.S. and European programs)
- Food and bioactive research (programs in Europe and the U.S., and at Canadian universities, including, in Atlantic Canada, Acadia University, Dalhousie University, Nova Scotia Agricultural College and Atlantic Veterinary College)
- Storage and postharvest-physiology research (U.S., Europe, South Africa and Asia)
- Berry crop breeding and genetics (collaboration and exchange of material with the U.S. and countries worldwide)
- Landscape ecology and pollination science (research is coordinated and shared with the U.S. and Latin America)

As a result of the 1994 Program Review, the poultry program was moved to the Nova Scotia Agricultural College in Truro and combined with the College's program. Four poultry barns, a feed mill and a hatchery were closed or relocated to the College. Kentville's primary research responsibility was refocused on berry crops and tree fruit production, storage and processing. The Kentville Research Centre changed its name to the Atlantic Food and Horticulture Research Centre in 1995 to reflect its mandate.

In 1997, the Centre initiated a new strategy for environmental sustainability of agriculture and the agri-food sectors. The Centre continued to develop integrated pest management strategies for pest control in tree fruit and berry production. Alfalfa leafcutter bees were found to be an excellent pollinator for blueberry flowers and a good alternative to honey bees for the rapidly expanding blueberry industry. In addition, programs for studying the impact of agricultural practices on water quality were expanded.

Reflecting changes made to the Department's structure and objectives in 2001, research at Kentville became focused on three new national programs: sustainable production systems, food safety and quality, and environmental health.

Berry crop research has continued to support the industry, with new strawberry cultivars released and now widely planted throughout Eastern and Central Canada, as well as the northeastern and north-central United States. The harvest season of highbush blueberries was extended using shading and plastic tunnels. In collaboration with the wild lowbush blueberry industry, high-capacity harvest containers were developed that maintain fruit quality while increasing the efficiency of harvest, transport and processing.

Apple research identified methods to optimize fruit size and colour through proper irrigation, management of crop load, and by assessing rootstock effects on productivity. Optimized timing of the harvest, pre-storage conditioning treatments, and optimized controlled-atmosphere storage were determined to provide high-quality Honeycrisp apples for more than 10 months of the year.

The Kentville Farm Facility

The Centre maintains its original red barn as well as Blair House, the original Director's house. Blair House now houses offices of the Nova Scotia Fruit Growers' Association and Horticulture Nova Scotia, as well as a museum that conserves the history of the local apple industry. Experimental land (187 hectares) is located adjacent to the main building and within 12 kilometres of the Centre at the Sheffield Research Field Site (77 hectares). The grounds of the main complex are endowed with expanses of azaleas and rhododendrons, some of which were bred by AAFC, making the Centre a prime location for graduation and wedding photographs.

To support the burgeoning market for organically grown produce, Kentville researchers are engaged in both ongoing and new research on sustainable production practices. Strawberry plants have been bred with natural resistance to angular leaf spot. A fungal complex responsible for replant disease in apples was discovered, and an effective control treatment was developed using compost applications. Safe alternatives to broad spectrum insecticides for controlling pests in tree fruits have been developed that include biological agents (parasitoids, predators and pathogens), nontoxic, narrow spectrum insecticides such as insect growth regulators, pheromones for mating disruption, and cultural controls, such as the modification of orchard ground covers.

Research at Kentville is placing increasing emphasis on food safety and quality. Research determined the ecology of human pathogens colonizing horticultural crops and ready-to-use and minimally processed produce. Rapid molecular- and culture-based methods to identify and characterize bacteria on leafy vegetables are being developed, and the role of contaminated irrigation water as a source of pathogen inoculum for lettuce is being examined. In addition, methods to assess and manage biological and chemical contaminants carried in livestock and poultry manure are being developed. An innovative technology has been developed that applies a mild-heat treatment to kill bacteria while preserving the quality and nutrition of fresh-cut fruits and vegetables, and a commercial prototype is now being tested at a food-processing facility. Additional antimicrobial treatments, including the use of heat, ozone, ultraviolet light, organic acids and lactic acid bacteria, have been evaluated.

Research to maintain and improve produce quality is ongoing. The impact on product flavour of cultivar, storage and processing technologies, and other factors, has been determined using sensory methodologies, and the chemical composition responsible for changes in flavour has been identified. Mechanisms for determining flavour formation in fresh fruits are being developed using molecular and proteomic methodologies.

Determining the impact of agriculture on the environment and minimizing detrimental effects are also among the Centre's goals. Over the past 12 years, Kentville's Water Quality Research Facility has identified the efficiency of nitrogen use in various cropping systems, including tillage, crop rotations, and the application of fertilizer and manure. In studies on biodiversity and its role in the resilience and stability of agricultural systems, the pollination rate of lowbush blueberry by wild bees has been linked to the composition and configuration of bee habitats within a one-kilometre radius of fields. These findings have resulted in new strategies to utilize wild bee pollination to ensure productivity and fruit quality.

People and Programs: 2011

A total of 138 employees including 27 researchers in three programs:

- Primary production: 8
- Food processing, product safety and quality: 12
- Environment stewardship: 7

Seven researchers are located off-site: five at the Nova Scotia Agricultural College, one at the *Université de Moncton* and one at Acadia University.

In 2002, Kentville was one of nine Research Branch sites selected for the testing of pesticide products for minor use registration.

In 2007, the management of the Nappan Research Farm, which had been under the auspices of Kentville until 1993, was transferred from Charlottetown to the Centre.

Research highlights over the past 25 years

Primary production agriculture

- Introduced eight strawberry cultivars that provide growers with high-quality fruit throughout the harvest season. Sixty percent of strawberries grown in Canada since 1986 are from cultivars bred in Kentville
- Developed new raspberry cultivars to improve on Nova, a 1981 Kentville release that is the leading raspberry cultivar in Eastern Canada
- Developed a winter-hardy thornless blackberry cultivar suitable for Eastern Canada
- Developed use patterns for herbicides that provided superior control of grass, broadleaf and woody perennial weeds in lowbush blueberry fields
- Developed techniques to extend the harvest of highbush blueberries by up to three weeks
- Identified previously unknown soil fungi in blueberry fields as a result of field burning, contributing to a new understanding of complex soil/crop relationships
- Developed blossom-thinning techniques in collaboration with the Nova Scotia Fruit Growers' Association that assure the repeat blooming of trees that produce the highly popular Honeycrisp apple
- Developed biological and cultural controls for orchard mites and other insect pests using long-term ecological studies and

mathematical modeling, and developed pheromone methods for pest monitoring and insect control methods that protect pollinators

- Discovered a soap-like substance produced by the bacteria that cause bacterial broccoli head rot; the substance allowed the bacteria to circumvent the protective coating of wax on the plant's surface
- Used supplemental lighting to improve the production and bloom quality of cut flowers and ornamental potted plants
- Developed environmentally-friendly technologies to control Monilinia and Botrytis blight in lowbush blueberries, thereby enhancing productivity and reducing fungicide use
- Improved scab control in apple by identifying more effective fungicides and better timing of their application, thereby reducing fungicide use
- Introduced a new apple variety, Masonova, which received a U.S. plant patent and is an ideal Empire replacement, having strong scab resistance

Food processing, product safety and quality

- Developed technologies to increase three-fold the storage life of fresh blueberries, expanding domestic and export markets, and extending market life and quality
- Demonstrated the importance of oxidative stress, and in particular antioxidants and antioxidant cycles, in maintaining the quality of horticultural products; also characterized the antioxidant capacity of a number of products, such as cauliflower, potatoes, spinach, and fiddleheads
- Showed that blueberries significantly lower plasma cholesterol in pigs, and that blueberries improve aspects of night vision in humans
- Patented the HarvestWatch technology, a chlorophyll-fluorescence-based system that is used internationally to improve storage conditions and extend the shelf life of apples

- Developed the Ethylene Potato Sprout Inhibitor, a new non-chemical control method for eliminating the unwanted sprouting of stored potatoes
- Developed novel dairy and non-dairy yogurt products using lactic acid bacteria fermentation
- Isolated and identified unique acetic acid bacteria that produce high yields of cellulose with the potential to be used to develop Nata products (Nata is a type of fermented food product most commonly used in a sweetened form as a candy or dessert. It is a chewy, translucent, jelly-like food product that gels through the production of acetic acid bacteria cellulose.)
- Developed a new method that produces a blueberry juice that has won numerous awards and created market opportunities for growers
- Formulated optimum temperature recommendations for perishable foods moving through commercial distribution systems, and determined how temperatures can be controlled to limit loss and improve food safety

Environmental stewardship

- Linked the pollination of lowbush blueberry by wild bees to the composition and configuration of habitats within a one-kilometre radius of fields leading to better management of natural habitat and improved pollination efficiency
- Identified differences in how maritime cropping systems use nitrogen, leading to new management practices, improved nutrient conservation and environmental protection
- Developed non-chemical alternatives for a number of major pests, including tarnished plant bug and black vine weevil, to reduce overall pesticide load on the environment
- Developed the Agri-Environmental Indicator of Wildlife Habitat as a key step towards improved stewardship of agri-ecosystems

The Atlantic Food and Horticulture Research Centre serves the needs of a diversified and growing agri-food industry that contributes significantly to the economy of the region and the province. Research extends from primary production through postharvest storage and transportation to food processing and technology, with emphasis on product safety and quality, and environmental stewardship. The main Centre facilities consist of a laboratory and office complex, a fully equipped food pilot plant, a multi-service phytotron with modern greenhouses, growth chambers, pesticide storage, and disposal facilities.

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Nappan Research Farm
Nappan, Nova Scotia

D. Mark Hodges, Research Manager, Research Branch, Kentville
Roy Bush, Research Manager (2003-2008), Research Branch, Kentville
Charles Forney, Research Scientist, Research Branch, Kentville

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The Nappan Experimental Farm, currently named the Nappan Research Farm, was founded 125 years ago to test agricultural methods and technologies for several agricultural products and practices, notably forage crops, livestock production and nutrient management. With the advent of other research centres to meet the specific needs of each province, Nappan has gradually narrowed its focus to beef production and the economical production of livestock feeds.

The early years, 1886–1985

The Nappan Experimental Farm was one of the original five experimental stations created by the federal government in 1886. The site was chosen because it was located in a good agricultural area, one that did not suffer the extreme climate conditions experienced elsewhere in the region. It was close to all three Maritime Provinces and was located on the Canadian National Railway main line to Halifax, which made it accessible to government officials and other scientists from Ottawa.

The Farm was set up as a complete experimental farm, conducting research on all relevant crops and livestock. Nappan was unique because approximately one half of the land base consisted of reclaimed wetlands or dykelands. It is the only research site in North America capable of comparing dykeland and upland mineral soils under a single set of climatic conditions. From the beginning, daily weather records have been collected and submitted to Environment Canada.

In the late 1950s, some researchers were moved from Nappan to other centres in the region, and significant collaborative programs evolved within the region. The first program to move was poultry research, which was transferred to Kentville. Dairy research was moved to Fredericton and Charlottetown. Both beef and sheep work were conducted at Nappan and Fredericton, with intensive rearing in confinement at Fredericton, and feedlot, breeding and pasture work at Nappan. In the 1960s, a portion of the swine research was moved to Fredericton and then to Ottawa.

In the 1960s, the federal Department of Agriculture's Regional Development Branch established a number of Record of Performance Centres for the various classes of livestock across the country. Nappan was chosen as the Centre for both beef and swine. With the downturn of the swine industry in the late 1980s, the swine centre was abandoned, and the Department reclaimed the buildings for beef research. The beef centre exists today as the Maritime Beef Testing Society—a privately owned organization—with support from Maritime provincial governments and industry. Interaction between the Testing Society and the beef feedlot trials at Nappan led to significant changes to feeding protocols for beef.

The beginning of the second century of research, 1986–2011

At the beginning of this period, the sheep research program was phased out, though live sheep were maintained for pasture studies. Sheep management and breeding work was continued at the Nova Scotia Agricultural College, with the Nappan flock being used for replicated trials. For Research Branch, sheep research for Eastern Canada was consolidated in La Pocatière, Quebec.

Research and Programs

In 1986, the Farm had five researchers working on forage crops, soil management, sheep management, ruminant nutrition, beef management and swine management.

Two beef research programs (nutrition and reproductive physiology) were established at Nappan, with scientists physically located on-site. Programs in soil nutrient management, forage breeding and field management were also conducted at that time.

Following the 1994 Program Review, three programs were retained at Nappan: beef nutrition, soils and forage breeding.

The beef nutrition work focused on available nutrients, better ways of preserving forages to conserve nutrients, and grazing management of beef animals on pasture to reduce imported feed grains and to optimize animal growth and plant longevity in pasture stands. During this period, it was demonstrated that growth in beef animals raised on a silage-based diet was similar to that of animals raised on a hay-based diet, leading the Maritime Beef Testing Society to change the diets of its animals, which in turn has made the program more cost effective.

The soils work focused on soil structure and nutrient availability as it applied to forage growth and longevity in pasture and harvest stands. Results demonstrated the impacts of grazing and winter freeze-thaw cycles on soil structure in pasture situations, and the value of compost and other soil amendments on soil structure and nutrient availability.

The forage breeding work focused on superior cultivars of forages that provide valuable sources of nutrients for ruminant (primarily beef) production. Some of the pioneering work on the quality of forage preserved in large, round, plastic-wrapped bales originated at Nappan. Use of this technology is now widespread, with users benefiting from the knowledge developed at Nappan. New breeds of forage plants have originated from both the breeding program and from ongoing field assessment of plant hardiness under mechanical clipping and field grazing.

In 1993, the Nappan Experimental Farm was renamed the Nappan Research Farm. In order to reduce the administrative overhead and integrate the livestock program in the Maritime Region, management of the Research Farm was transferred from Kentville to Fredericton, where it remained from 1993 to 1996, then to Charlottetown (1997-2007), and then to the research centre in Kentville (2007-present). A researcher was the main contact point and was responsible for interacting with the farm manager.

New facilities were created for the intensive feeding of beef, including a new winter-feeding barn, horizontal bunker silos, and—after the closure of the swine program—a retrofitted swine Record of Performance facility. Some of the buildings were dismantled, being too old, unsafe, or unnecessary.

The National Research Council in Halifax conducted pasture trials on the effects of applying seaweed to pasture, on the load of potential pathogenic organisms, and on the incidence of "ovine ill thrift", a condition associated with malnutrition or nutritional deficiencies that affect weight gain and health despite availability of good feed and pasture.

In 2011, two researchers report to Nappan: a nutrient management researcher and a beef production researcher. In addition, Agriculture and Agri-Food Canada researchers from other locations make use of Nappan's fields and facilities.

Research highlights over the past 25 years

Swine research

- Established feeding conditions for incorporating potatoes and potato steam-peel waste into swine diets, thus improving waste utilization and swine productivity
- Developed feeding protocols for the use of root-vegetable culls in swine rations
- Measured and developed guidelines for incorporating fish waste, preserved in various ways, into swine feed
- Showed the potential for pasturing sows both winter and summer, increasing swine productivity

Nutrient management

- Improved utilization of organic (manure and compost) and inorganic nutrient sources, contributing to enhanced environmental performance
- Improved utilization and crop diversification on dykeland soils, ensuring soil protection
- Discovered that cement kiln dust (a waste product), when surface applied, was a better liming amendment than agricultural lime, and offered the secondary benefit of supplying potassium to the forage

Forage crops

- Demonstrated that pastures seeded with domesticated cultivars are gradually re-colonized by native and naturalized species, improving agronomic performance
- Demonstrated that animal productivity could be improved by increasing the pasture's legume content, contributing to improved livestock management
- Showed that simple forage mixtures provide the most benefit to livestock nutrition when they are grown in uniform pastures with high fertility and are intensively managed
- Devised and implemented multiple initiatives to overcome poor persistence of forage legume species, leading to more sustainable and nutritional pasture land
- Developed novel methods for screening forage germplasm, and expanded the genetic base by identifying new germplasm through an evaluation of currently available and newly developed cultivars in Canada and Europe, leading to more diverse and sustainable pastures
- Developed and introduced 15 new forage cultivars, including five that were supported for registration in Canada, thus expanding the genetic base for more effective pasture management and sustainability

Beef production

- Established conditions for drying and baling haylage before conserving it in large, round, plastic-wrapped bales, improving the efficiency of winter livestock feeding
- Established that silage as a feedstock to support livestock growth is the equal of diets of hay plus grain; this collaborative work with the Maritime Beef Testing Society has resulted in gains in profitability and efficiency of production

Presently, the Nappan Research Farm focuses its research mandate on beef production from conserved forages and pasture, and the economical production of these livestock feeds. It is the only departmental livestock research farm in the Atlantic Provinces.

Potato Research Centre
Fredericton, New Brunswick

Agnes Murphy, Research Scientist, Research Branch, Fredericton

The Fredericton Experimental Station was created in 1912. In the early years, research focused on potato diseases, insect surveys and taxonomy, and the emerging use of insecticides on certain crops. Staff also provided advice to local growers. Over the years, research was initiated on potato breeding with emphasis on disease resistance, virus-transmitting insects such as aphids, fruit crop production, livestock nutrition, and soil fertility. The past quarter-century has seen significant federal investment in the facility that has allowed the Centre to concentrate and expand its research capacity in potato development, understand interactions between pests and pathogens, and address the influence of agriculture on the environment. As it approaches its centennial in 2012, the Centre — now known as the Potato Research Centre — has earned an international reputation for research ranging from germplasm enhancement to crop protection and environmental science.

The early years, 1912–1985

In 1912, the Department of Agriculture purchased 182 hectares of land to establish an experimental farm in Fredericton. That same year, an entomology laboratory was established at the University of New Brunswick, and three years later, a pathology laboratory was opened in downtown Fredericton.

Researchers worked on potatoes, addressing the diseases that were affecting this important crop. Early pathology activity included the introduction of spray regimes for the control of fungal diseases such as late blight of potatoes and apple scab. Early entomology work involved insect surveys, biological and taxonomic studies, and insecticide use—in orchards, and on potatoes and a number of other crops. Information services were also provided. Extensive efforts were made to improve livestock feeds to increase productivity along with the health of cattle and dairy animals. Similarly, studies to improve soil fertility were initiated, with the emphasis later shifting to address the adverse effects of heavy agricultural machinery on soils. Information and extension services were also provided to the farming community.

Although crosses had been made for several years beforehand, a distinct potato breeding project was established in 1933 with the objective to improve resistance to viruses and late blight. By 1943, the Experimental Farm Service had named the Fredericton farm as Canada's Potato Breeding Centre, and the Department established a national trial system in 1947. Five regional potato recommending committees were formed about 10 years later.

In the late 1940s, sub-stations were established in three other New Brunswick counties: Alma (potato breeding), Tower Hill (blueberries) and McGowan's Corner (strawberries and horticultural crops).

The postwar years brought an emphasis on research into new techniques for the study of plant viruses. Some research carried out at Fredericton earned international recognition. For example, researchers showed that the spread of the potato virus Y could be reduced by as much as 80 percent by spraying plants with a water-oil emulsion. After the merger of the Science Service and the Experimental Farm Service in 1959, new laboratory-office facilities were constructed, and, in 1960, the farm was renamed the Fredericton Research Station.

In the late 1960s, a major review of the potato breeding program took place that set new directions. Germplasm improvement programs based on both wild and cultivated relatives of the potato were initiated. These programs identified several sources of resistance to disease and pests, particularly viruses and late blight. Intercrossing, and many years of selection for adaptation to the long growing days of North America, broadened the gene pool in the conventional breeding program. The primitive germplasm collection also facilitated insights into the inheritance of traits.

Also, an agricultural engineering research was established to reduce harvest losses in potatoes and grain and to improve forage preservation. Research continued to address energy conservation and quality control in above-ground potato storages that had replaced the traditional below-ground storages.

During the potato leaf roll virus epidemic of the early 1970s, entomologists initiated an aphid warning program that provided information on the prevalence of aphids. Top kill dates for seed potato crops could thus be timed to minimize the spread of mosaic viruses by aphids. Once leaf roll subsided, researchers turned their attention to the identification and ecology of the aphids responsible for spreading mosaic viruses.

By the mid-1980s, researchers were grouped into four sections: potato breeding; pest management; livestock and crops; and engineering, horticulture and soils.

The beginning of the second century of research, 1986–2011

In 1986, the research complex included a three-storey main building housing laboratories and offices, an adjoining greenhouse, a dairy facility, a beef barn, an entomology lab and a greenhouse unit. It also had potato breeding greenhouses, a farm services centre with cold storage, and various outbuildings for field crop production, maintenance, and storage.

The Centre's director lived on-site in Hilton House, overlooking the Saint John River. Library services were provided on-site and an extensive collection of reference materials and journals were maintained.

People and Programs: 1986

There were 32 researchers grouped into four broad sections with wide-ranging research mandates:

- Potato breeding: 7, including a researcher located at the University of Guelph
- Potato pest management: 8
- Livestock and crops: 8
- Engineering, horticulture and soils: 9

The potato breeding section had a national mandate, with an emphasis on producing improved French fry, chip and fresh-market potato cultivars. Two new cultivars, AC Brador and Donna, were released exclusively for offshore markets. Variety trials were conducted in New Brunswick, Prince Edward Island and Nova Scotia, and a number of promising selections were included in a cooperative trial system in the eastern United States.

Shepody Potato

In 1980, the Shepody potato, which had been developed at Fredericton, was licensed for production. Over the past 25 years, it has become one of the most popular varieties for French fries in Canada. It is also grown in the U.S. and internationally.

The pest management section concentrated on the identification and management of potato diseases, the development of serological detection methods, disease forecasting and insect-host interactions. Researchers demonstrated that the use of virus-resistant cultivars would drastically reduce the spread of disease.

In the animal and crops section, feeding trials were conducted to evaluate the merits of local, alternate protein sources for beef cattle feed. Crab meal, a by-product of the region's shellfish-processing industry, was found to be slowly digested, so its potential was investigated as a protein supplement for beef cattle being fed silage. Other high-protein feeds, such as bypassed peas and canola screenings, proved satisfactory as protein supplements for cattle that are fed corn silage.

Long-term fertilization trials established in 1960 to investigate the effects of nitrogen, phosphorous and potassium (N-P-K) on the production of timothy grass continued to be useful. Trial data demonstrated the importance of a proper N-P-K balance to the long-term productivity of the major forage types grown in Atlantic Canada. Handling efficiencies were developed to facilitate silage experiments using an Ag-Bag silage compactor to fill horizontal plastic bags that mimicked conditions in large, upright commercial silos.

In the engineering, horticulture and soils section, engineers examined the effects of various conditions on the incidence of damage at harvest. Several aspects of fruit crop production were investigated. The effects of several mulching materials on marketable yield strawberries were also compared. Soil and nutrient losses under various cropping practices were determined from runoff erosion plots established on 8-percent and 11-percent slopes near Grand Falls. Soil loss, it was found, could be reduced dramatically by planting along the contour.

By 1989-1990, 24 researchers at the station were working in two broad areas: potato research; and animal and crop management. The underlying themes remained similar to those that had shaped research in previous years, with progress being reported in the development of new potato chip cultivars, and in increasing resistance to various diseases through intercrossing.

By 1991, soil and water research had become important as concern grew about the effects of agriculture on drinking water. A correlation between the intensity of land use for potato production and the nitrate (NO_3) levels found in groundwater was demonstrated.

Seed-Trade Missions

Researchers have worked with colleagues at the New Brunswick Department of Agriculture to promote the New Brunswick seed industry in international markets, have participated in seed-trade missions to China, Indonesia, Malaysia and Thailand, and have coordinated international delegations visiting the potato industry in Atlantic Canada.

Researchers have also participated in the missions of organizations such as the Canadian International Development Agency, United Nations Development Program and the United States Department of Agriculture. The objective of the missions was to provide advice and give lectures to researchers and agronomists in Australia, Chile, China, Japan, New Zealand and South Africa. Topics included: introducing and assessing varieties; crop management practices; quality and disease evaluation; and environment and water quality.

After the 1994 Program Review, beef research was consolidated at the Nappan Research Farm in Nova Scotia. The dairy herd was acquired by the Atlantic Dairy and Forage Institute (a private research organization established south of Fredericton to serve the dairy producers of Atlantic Canada), and both agricultural engineering programs and horticulture research were phased out.

In 1997-1998, the mandate of the Centre shifted, and it was renamed the Potato Research Centre. Over the next several years, the Centre began a new chapter by staffing researchers in the emerging fields of molecular pathology, molecular genetics, and bioinformatics. For the first time, a programmer-analyst was hired, reflecting a general increasing reliance on personal computing. During this time, researchers established collaborative projects with industry partners under the Agri-Food R&D Matching Investment Initiative.

In 1998, the research centre formally implemented an Accelerated Release Program, responding to the potato industry's wishes to become involved earlier in the typical 10- to 12-year evaluation process required for new variety development. Under this innovative program, promising potato selections were offered for further assessment by industry after six years of testing, to gauge their market potential.

Since 1998, more than 125 potato selections have been offered through the two-phase process, with participants from nine provinces involved. Several cultivars, including Impact, Tarnick and Tenace, were registered and have been licensed with commercial partners. In 2004, the regional retailer Co-op Atlantic was granted exclusive rights to the production of a variety—the first arrangement of its kind in Canada. The variety was named Rochdale Gold-Dorée to commemorate the town where the early co-operative movement was born in 1844. Exclusive rights were abandoned in 2010.

From 2001 to 2003, the Potato Research Centre underwent a major retrofit and upgrade that included new laboratories, growth rooms, offices and greenhouses, and a natural gas heating system with back-up generator capacity to safeguard research materials. The new premises were occupied in 2003. The former laboratory wing and the greenhouse complex, both dating from the 1960s, no longer met building standards and were demolished.

To support field research, a new 1,000-square-metre building was constructed in 2007, with better facilities for processing soil and plant samples, and increased storage. In 2009, construction began on a purpose-built laboratory to ensure the security of the Potato Gene Resources Repository. This *in vitro* collection of more than 150 heirloom cultivars and Canadian-bred potatoes is part of the Plant Gene Resources of Canada Network coordinated by the Saskatoon Research Centre.

Research Partners

- Numerous Canadian universities, and provincial and regional research organizations
- Aalborg University
- BioAtlantech
- Brazilian Department of Agriculture
- Cork University, Ireland
- Canadian Executive Services Organization
- Canadian Potato Genome Project
- Canadian Forest Service, Fredericton
- Chinese Academy of Agricultural Sciences
- Cornell University
- Costa Rican Ministry of Agriculture
- International Institute for Tropical Agriculture, Ibadan, Nigeria
- International Potato Centre, Lima, Peru
- Macaulay Institute, Craigiebuckler, Aberdeen
- NRC Institute for Nutrisciences and Health
- Princeton University
- United States Potato Genebank, (part of the USDA National Plant Germplasm System)
- Scottish Crop Research Institute
- *Université Picardie*, Jules Verne (Amiens, France)
- University of Helsinki, Division of Ecology and Evolution

The past quarter-century has seen the Centre maintain its international reputation for germplasm enhancement through selection for better parents, in part because of its use of Andean and wild species germplasm. The release of F87084 in 2001 demonstrated the collaborative and incremental nature of potato breeding. This fertile and well-adapted parent has inherited multiple disease resistances from diverse sources, including selections from the U.K., Germany, the Netherlands and the U.S.

Centre researchers have been active in molecular biology and genomics research for more than a decade. Between 2004 and 2007, the Potato Research Centre was involved in the Canadian Genome Project, a $4-million multi-institutional endeavour of Genome Atlantic, the eastern regional arm of Genome Canada. To accommodate this large-scale project, new laboratory equipment was acquired, and new technology platforms and extensive molecular libraries were created.

New Uses for Potatoes

The Centre led the establishment of the BioPotato Network, launched in 2008. The network team included more than 32 researchers from governments, universities and research institutes across Canada who worked together to identify new uses for the potato that can provide new market opportunities—as functional foods, neutraceuticals, pharmaceuticals, and as a source of starch and polymers suitable for bioplastics and bio-pesticides.

Innovative approaches have greatly improved understanding of the biology and ecology of virus vectors and of the Colorado potato beetle. They include the use of micro-telemetry to track insect movement; the devising of cost-efficient means to rapidly detect the development of resistance to insecticides by Colorado potato beetles; the development of physical barriers, such as plastic-lined trenches, to prevent beetle infestations; the use of molecular techniques to investigate the transmission of viruses by aphid vectors; and the development of measures for controlling scab. Biochemical investigations have thrown light on host pathogen interactions in scab disease and identified the phytotoxin thaxtomin, which is produced in response to infection.

An international effort to map the potato genome and its 84 million DNA base pairs was completed in 2010. Advances in the understanding of potato genetics and physiological pathways, and the emergence of powerful new technologies, are helping researchers to pinpoint more accurately the genes responsible for desirable traits, and to understand the associations between genes. The application of these new technologies will guide the conventional breeding process, allowing selection of the traits necessary to produce improved parents and potato selections suitable for the future.

The Centre's research on soils and the impact of agricultural production on air and water quality has expanded to include studies of the potentially harmful impact of agricultural activities. In 2007, two Environment Canada researchers joined the Centre's research staff, facilitating a partnership approach to environmental sustainability with respect to agricultural systems. The Centre's environmental researchers have also become involved with Agriculture and Agri-Food Canada's Watershed Evaluation of Beneficial Management Practices, a national project to examine best practices for mitigating sediment and runoff issues related to water quality.

By 2010, collaboration between the laboratories at the Centre had become very efficient. Researchers combined resources and expertise to study potatoes from many different angles. One example is the study of a potato population generated from an adapted diploid germplasm in order to understand mechanisms and associations between multiple traits, including maturity, scab resistance and chipping quality. This approach maximizes output and strengthens collegial relationships between laboratories and within and between research institutions. Collaboration has been facilitated over the past 25 years by major developments in personal computing, instant electronic communication, and information capture and retrieval capabilities. Today the Centre has 13 researchers on staff.

Benton Ridge

The Benton Ridge Potato Breeding Field Site, 100 kilometres west of Fredericton, was established in 1975 to replace the potato evaluation facility at Alma, New Brunswick. It remains the principal site for seed multiplication, grading, and storage related to potato enhancement. Field evaluation and selection of early-generation potato breeding lines are conducted at this 345-hectare location. Over the past 25 years, Benton Ridge has acquired new sheds and machinery, and has improved its cold storage capacity.

Research highlights over the past 25 years

Germplasm enhancement

- Developed and registered more than 40 new potato varieties in collaboration with departmental potato breeders at Guelph, La Pocatière, Lethbridge and St. John's
- Provided to industry, through the Accelerated Release Program, 114 potato selections for evaluation and the opportunity to acquire exclusive rights for production
- Developed the potato variety Shepody that became one of the top French-fry varieties in the world

Entomology

- Reported resistance to insecticide in several populations of Colorado potato beetle
- Developed and used micro-telemetry to monitor insect movement

Livestock

- Determined the nutritive quality of forages during their primary growth phase and the changes in nutritive quality in response to climatic variation over a six-year period

- Established that Vitamin E levels in milk increased only when both Vitamin E and selenium were added to the diet

Engineering

- Developed an instrumentation system for a trailed subsoiler to record operating parameters; data were recorded by an ultraviolet-light (UV) chart recorder for field verification and were transferred to magnetic tapes for analysis

Soil and air

- Determined soil and nutrient losses from runoff erosion plots with respect to various cropping practices; soil loss was greatest on land under potato production, but could be reduced dramatically by planting along topographic contour lines; contour planting also reduced the loss of nutrients applied as fertilizers
- Identified a means to mitigate nitrate contamination of vulnerable ground water aquifers

Methodology

- Developed or applied special procedures and instruments to facilitate various key operations involved in production systems and fundamental research: oil sprays to reduce virus transmission; quality and disease evaluation systems; a sugar meter; a small-plot harvester; aphid counts for seed production
- Isolated acetylated sucrose esters from type B trichomes; this was predicted to be useful in identifying pest-resistant domestic varieties and for taxonomic delineation
- Received American and Canadian patents for research on somatic embryogenesis in potato
- Improved efficiencies in the production of first-generation potato seedlings by the adoption of bedding plant technology

- Discovered phytotoxins linked to common potato scab; this discovery narrows the search for resistant varieties and accelerates the development of new varieties
- Developed new classification models to identify potato virus Y (PVY), which help Canada respond to disease outbreaks and to resolve trade issues
- Created new molecular tests for potato virus detection to help avoid new outbreaks
- Categorized cultivar tolerance levels to field infection of potato virus Y (PVY), and to leaf roll, using cluster analysis
- Determined that the viability of tuberlets produced from leaf bud cuttings was directly proportional to their size
- Demonstrated that bromoethane for dormancy release is superior in terms of toxicity and cost to the industry standard, rindite

Research today, at the Potato Research Centre in Fredericton, is concentrated in three areas: potato germplasm enhancement; crop protection; and enhancing the environmental performance of potato production systems.

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Senator Hervé J. Michaud Research Farm
Bouctouche, New Brunswick

Jean-Pierre Privé, Research Scientist, Research Branch, Bouctouche

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Since the creation of the Senator Hervé J. Michaud Research Farm in 1978, formerly known as the Hervé J. Michaud Experimental Farm, its mandate has evolved from serving the regional needs of the francophone farming community to providing new knowledge and technologies for sustainable production practices for fruits and vegetables, both regionally and nationally. This research has led to the adoption of new agro-ecosystems that promote the growth, development and increased quality of fruits and vegetables while reducing chemical inputs. Collaborative studies with industry, universities and growers, and the addition of research facilities, buildings and qualified personnel, have made these advances possible. Farm researchers work with the Canadian horticultural industry to increase its competitiveness through greater knowledge, improved technologies and innovative strategies.

The early years, 1978–1985

The Senator Hervé J. Michaud Research Farm occupies a riverside property located 8 kilometres west of Bouctouche, New Brunswick. The Department created the 28 hectare farm: to reverse a trend that was taking improved land in eastern New Brunswick away from farming; to demonstrate the unique agricultural potential of various coastal soils in a maritime climate; and to connect with the French-speaking citizens of the area, who were developing a growing interest in agriculture.

The beginning of the second century of research, 1986–2011

In 1986, the Farm's assets consisted of three professionals and two buildings—the main administrative building and the machinery storage building. Open houses were held yearly in an effort to increase public awareness and foster private-public consultations.

The Farm's mandate focused principally on fruits and vegetables and the development of edible horticultural varieties best suited to Maritime coastal areas. Monitoring of grain, corn silage, and fodder turnip and grass varieties for their yield and nutritional quality ended in 1991. Through the 1990s, the work focused entirely on fruits and vegetables, since these were the most promising commodities for the area.

With the hiring of a new plant physiologist in 1991, the focus of fruit research turned towards the study of environmental stress and how it affects fruit growth and development, most notably in apples, raspberries and lowbush blueberries. This work included: the development of new strategies for testing cold tolerance in plants and tissues; the evaluation of crop responses to drought, wind, light and heat; and the development of new cultural and sustainable practices to help optimize carbon assimilation.

People and Programs: 1986

The Farm had 11 full-time employees, including two researchers and a superintendent serving as manager.

Vegetable research focused on soil preparation and tillage practices, plant spacing and population density studies, fertilizer and soil amendment requirements, and pest management strategies. Through innovations such as plastic mulches and row tunnels, the maturity and yields of sweet corn, tomatoes, pickling cucumbers and other market garden crops were advanced and increased.

Since the advent of the new millennium, the Farm has increased cooperation with other research centres (e.g. the Pacific Agri-Food Research Centre). The farm maintains close working relationships not only with other scientists in the Department but with international partners, universities, provincial specialists, horticultural industries and grower groups.

Since 2000, the fruit research program has focused on environmental stress physiology. Tolerance to cold temperatures of apple roots and raspberry tissues was explained using recent medical technologies, while information on the screening of apple rootstocks and raspberry varieties for cold hardiness, in conjunction with input from national and international breeders, helped growers make the informed choices necessary to foster more sustainable production practices.

The vegetable program tackled both environmental sustainability and the challenge of increasing economic sustainability for farmers. Researchers worked on a range of vegetable crops and systems, including the fine-tuning of nitrogen fertilization in peppers, the use of row covers and fall plantings to overwinter leeks until spring harvest, the evaluation of local clam-processing wastes as an agricultural soil amendment, and the development of a Maritime production system for sweet potatoes.

Since 2002, a growing portion of the work has focused on organic vegetable rotation systems, on how organic fertilizing amendments and compost become available over time, on understanding soil interactions, and on finding methods to intensify vegetable crops in rotation while building soil fertility.

In 2002, the vegetable crops team joined the Department's Minor Use Pesticides Program, becoming one of nine sites across Canada charged with evaluating "minor crop" pesticides. These evaluations support registrations of pesticides that are safer and more effective, including organic pesticides.

Research Partners

Research activities at the Farm have long been closely linked with those at other federal research centres, particularly in Atlantic Canada, but also at Saint-Jean-sur-Richelieu, Ottawa, Harrow, Guelph, Agassiz and Summerland. The Centre continues collaboration with provinces and universities, particularly with Moncton, Guelph, Laval, Nova Scotia Agricultural College and Dalhousie. As well, Centre researchers continue to work closely with the industry players, such as the Canadian Horticultural Council, the Organic Agriculture Centre of Canada, the New Brunswick Soil and Crop Improvement Association, the Coopérative Horticole, La Récolte de Chez-Nous, and Keddy Nurseries. They have also developed collaborative relationships with international universities and research organizations, including the U.S.: IR-4 Program (Minor Use).

The Farm reported to the Fredericton Research Station until 1994 and again from 2002 to the present time. From 1995 to 2001 the farm reported to the Atlantic Food and Horticulture Research Centre at Kentville, which had the horticulture mandate for the Atlantic Provinces. To reduce the administrative overhead cost, management of the Farm was integrated into that of the Potato Research Centre in Fredericton, starting in 2004. There are currently two researchers conducting research projects at the Farm.

Subsequent to the Farm's creation in 1978, a number of new buildings were added. They included a machinery storage/garage building in 1988, a pesticide building, a pesticide disposal pit, and a header house in 1990, a new greenhouse in 1993, which was upgraded in 1998, and a cold storage building in 2005.

Research highlights over the past 25 years

Vegetables

- Showed the interaction of availabilities of plant nutrients released by organic amendments through the mechanical weeding of organically managed plots
- Demonstrated the usefulness of clam processing wastes as an agricultural liming amendment
- Developed an overwintering system that makes it possible to plant leeks in late summer for harvest in June, allowing growers greater flexibility in supplying major retailers
- Showed that various varieties of sweet potato could be adapted for the Maritimes and supply various health-promoting phytochemicals

Fruit crops

- Developed a new methodology for cold-hardiness screening of apples and raspberries at the early stages of development
- Showed that companion planting and artificial and natural shelters reduce environmental stress from wind for blueberry and raspberry production
- Developed intelligent irrigation system for use in lowbush blueberry fields to ensure optimal plant growth, development and yield with minimal use of agrochemicals and irrigation water
- Developed original analytical methods to determine the critical associations between historical apple production data and climate for the Annapolis Valley; this has provided insight into the main climatic factors limiting production in this area and helped the application of offset management strategies (e.g. protected structures)

- Developed various agro-ecosystems (to optimize fruit quality and long-term raspberry production while reducing disease pressure) and applications—from optimizing raspberry cane management to providing protected structures preventing rain from splashing on plants

Minor Use Pesticides Program

- Generated data to support the successful registration of Spinosad® for use against the blueberry maggot in lowbush blueberry crops, giving blueberry growers good control within U.S-export tolerance limits, and allowing them to compete with U.S. growers

Farm researchers in Bouctouche work to develop new knowledge, tools and practices that increase the competitiveness of the industry by improving the understanding of complex interactions between biotic and abiotic factors in crop growth and production. Researchers are also working in organic horticultural research, having established long-term organic rotation experiments on-site in the first decade of the 2000s. The Minor Use Pesticides Program continues to generate data to support registrations of greener, newer pesticides for crop protection.

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Chapter 3, Quebec and Ontario

Soils and Crops Research and Development Centre
Quebec City, Quebec

Réal Michaud and Denis Angers, Research Scientists, Research Branch, Quebec City

The Soils and Crops Research and Development Centre was created in 1967 as the Sainte-Foy Research Station (now part of Quebec City) to conduct research on soils, forage and grain crops, plant-microbe symbioses and the winter survival of plants. With the emergence of public interest in the environment, the Centre initiated research related to greenhouse gases, water quality and manure management. A land resources unit joined the Centre in the late 1990s. The Centre is currently relying on the expertise of a balanced multidisciplinary team of researchers working towards increasing agricultural productivity and sustainability of forage-based cropping systems under cold and humid climatic conditions.

The early years, 1967–1985

The Sainte-Foy Research Station (now part of Quebec City) was established in 1967 at a temporary location belonging to the Faculty of Agricultural and Food Sciences at Laval University. In October 1970, the Station moved to a new federal facility located close to the university campus. The Station's initial mandate was to conduct research on soils, forage and grain crops, plant-microbe symbioses and the winter survival of plants.

The Station had responsibility for research programs and for the general administration of the La Pocatière, Normandin and Caplan experimental farms. The Caplan Farm ended operations in 1970. In 1982, the Station acquired the Jean-Charles Chapais Research Field Site established on the former federal animal quarantine station in Saint-David-de-l'Auberivière, near Lévis.

The beginning of the second century of research, 1986–2011

In 1986, the Station's scientific staff totaled 24 researchers. With a view to eventually establishing research capacity in Abitibi-Témiscamingue, the Station began field experiments in Évain, close to Rouyn in Abitibi. Since 1987, the Sainte-Foy Station has rented 30 hectares at Lévis-Lauzon as part of the consolidation of its research efforts in the Quebec City region.

In 1989, administrative and scientific responsibilities for the La Pocatière Farm were transferred to the Lennoxville Research Station in order to better respond to the Farm's sheep production mandate. Finally, in 1993 the Station became the Soils and Crops Research and Development Centre, the name by which it is still known today.

Soils and environmental research

In the early 1990s, the Centre recognized that interest was growing among Canadians with respect to the quality of water, air and agricultural soils. In response, research shifted toward developing soil quality indicators, in particular with respect to soil organic matter, and toward developing better management of the cycle of nitrogen and phosphorus in order to minimize losses through diffusion into the environment. In the late 1990s, the Centre added research activities related to greenhouse gases, water quality, and the management of manure and other residual products. This research has influenced the way in which farming is conducted in Quebec and Canada through the development of national environmental risk assessment indicators and recommendations for science-based policies.

Soil Mapping

In the 1990s, a federal land resources unit was appended to the Centre. Soil survey and taxonomy specialists pursued soil mapping in the St. Lawrence Lowlands while developing a program of research in precision agriculture and the spatial variability of soils. In addition to providing spatial analysis of crop yields, the specialists' approach made it possible to understand key productivity factors and environmental risks associated with the management of nutrients at the field, farm and watershed levels.

Research was conducted on nutrient dynamics in relation to soil fertility, and air and water quality, on new methods of laboratory soil analyses, and on novel approaches to measuring the impact of nutrient management at the field and watershed levels. Research on phosphorus highlighted the potential problem of phosphorus accumulation in agricultural soils. Since 2000, new methods and techniques for improving soil fertility with respect to nutrient availability and fertilization recommendations were developed. These techniques used plant- and soil-based tools to diagnose nitrogen and phosphorus deficiencies in forages, wheat, potato and corn. A research program was developed on the management of farm manure at the field, farm and watershed levels. As well, research was initiated in order to quantify emissions of greenhouse gases and ammonia from agricultural soils at regional and national scales, and to develop mitigation measures.

Over the years, research on soil quality and organic matter has involved the study of soil structure and carbon- and nitrogen-cycling, with the objective of reducing soil degradation and greenhouse gas emissions. The fundamental mechanism that controls structural and carbon stabilization has been identified in the soils of Canada. As well, the potential of various management practices to sequester atmospheric carbon in the soils of Eastern Canada has been determined. The Green Plan initiative in 1994, the ice storm special program, the Program of Energy Research and Development in 1998, and the Good Agriculture Practices program in 2003 allowed researchers at the Centre to discover the importance of microbial activity at cold temperatures with respect to denitrification and nitrification of residual nitrogen in agricultural soils during winter.

Since 1980, soil microbiologists have been working extensively on selection and characterization of *rhizobium* adapted to environmental and agronomic Canadian conditions, resulting in a unique collection of several *rhizobium* species and strains. Researchers have also determined the diversity of the autotrophic bacteria responsible for the nitrification process (nitrifiers), using advanced molecular biological techniques.

Weed Research

The research program in weed science has focused on the effects of rotation, fertilization, mechanical weed control and other farming practices on populations of weeds and yields of grain, corn and soybean. After the initial work on the inventory of weeds in Quebec, research focused on the study of weed biology, including the development of quackgrass growth models and the study of the risks of gene transfer between herbicide-resistant canola and related weeds (wild mustard and radishes). More recently, research on weeds has focused on the distribution and management of allergenic and newly introduced exotic weeds, and on reducing herbicide use and environmental impacts by developing methods of localized application.

Forage crop research

Historically, the genetic improvement of alfalfa and timothy has been at the core of the forage program. Work on enhancing forage quality was strengthened using new quality attributes such as protein quality and sugar concentration. Research on the molecular biology of forage species was initiated in the early 1990s and its rapid expansion led to the relocation of personnel to a laboratory in the new Envirotron Pavilion at Laval University, where collections of genes were accumulated for use in the development of marker-assisted selection.

Winter survival of forages remains a major theme of research at the Centre. The initial research established levels of cold-weather hardiness under field conditions, and the range of freezing tolerance in commercial cultivars of several forage species. In the mid-1990s, the effects of ice encasement and anoxia on the biochemistry and physiology of forage crops in Eastern Canada were investigated, and research on the molecular aspects of cold hardening was initiated. Recently, a selection methodology was devised—performed entirely indoors under environmentally-controlled conditions—that allowed significant increases in the freezing tolerance of alfalfa. This approach, based on recurrent selection, has led to the development of molecular markers and acceleration of the selection process of cultivars better suited to Canada's unique production conditions.

Forage quality in relation to animal health and performance has received more attention over the past ten years. A forage production system for dry cows was developed that resulted in the implementation of integrated agronomic practices that include choice of species and fields, stage of development at harvest, and fertilization. More recently, research on increasing the energy in forages, with the objectives of improving nitrogen-use efficiency and the productivity of ruminants, yielded specific management practices and recommendations with respect to the time of cutting, swath management and the choice of species. Genetic selection was also identified as an approach to increasing the energy content of forages.

The impact of climate change and of increasing atmospheric carbon dioxide (CO_2) on Canadian forage crops has emerged as the focus of recent research efforts. Agro-climatic indicators have been developed and used to predict the impact of climate change on the risks of winter damage to forage crops. Current research focuses on yield and nutritive value. The risk of significant loss as a result of poor weather conditions at harvest has prompted the development of technologies for intensive mechanical forage conditioning and forced ventilation. More recently, agricultural engineering research has focused on harvesting biomass crops such as corn stalks and willows.

Pioneering research on the use of lignocellulose biomass for the production of ethanol and other products was initiated in the mid-1990s as part of the Green Plan. The Centre was co-leader of the national Cellulosic Biofuel Network and became an integral part of several streams of research in that area. Researchers have explored new market opportunities—from the development in the 1990s of a platform for producing proteins in alfalfa for industrial and pharmaceutical uses to the development of a patented technology for the expression of cell-wall-degrading enzymes in alfalfa.

Cereal grain research

Initially, the cereal grain research program focused on increasing production efficiency and improving the quality of grains, in particular barley and oats. Emphasis was placed on the development of cultivars better adapted to soil and climate conditions as well as on protection against weeds, diseases and insects. The incorporation of resistance against barley yellow dwarf virus in these two species allowed significant progress in yield stability. Several cultivars were registered, including the Chapais barley cultivar, which remains a reference cultivar for this species and is a favourite choice for rotation with potatoes. In 2009, the cumulative farm gate value of Chapais over 17 years was estimated at $600 million. The oat cultivar AC Rigodon, developed by the Centre, was equally successful, with a cumulative farm gate value of $250 million.

In the early 1990s, grain research gradually moved away from barley and oats to concentrate on bread wheat, with an emphasis on quality and Fusarium tolerance. In the past decade, research has concentrated on the study of root and seed diseases and on the development of germplasms that embody multiple resistances to biotic and abiotic stresses, in support of other Canadian grain breeding programs. Because Fusarium head blight remains a major cereal disease in Canada, the development of germplasm with multiple resistances is being pursued. Genetic resources are shared with other departmental cereal programs and with the private sector.

Research highlights over the past 25 years

- Developed a better understanding of the cycles of essential nutrients (e.g. phosphorus and nitrogen), resulting in the development of recommended management practices that increase the utilization efficiency of nutrients from organic and inorganic fertilizers and decrease their losses to air and water
- Showed that the cold-adaptation trait of *Mesorhizobium* isolated from the Canadian high arctic has the potential to improve symbiotic nitrogen fixation at low temperatures
- Showed that indigenous *Bradyrhizobium* isolated from soybean and corn rotations on Quebec farms were genetically diverse, leading the way to the selection of Bradyrhizobium strains that are more effective for use in soybean inoculation
- Produced soil maps in the St. Lawrence Lowlands
- Established long-term plots to determine the impact of various rotations and tillage practices on crop yields, soil properties and weed dynamics
- Integrated image-analysis technologies that allow the development of crop loss prediction models to support low-rate herbicide applications
- Developed an indicator of the risk of phosphorus contamination of water in Canadian agricultural watersheds, including the first national assessment of soil phosphorus enrichment

- Under the cereal breeding program, released more than 30 cultivars of barley, oats, wheat and triticale, and shared valuable germplasms with private industry partners.
- Developed cultivars, including the Chapais barley cultivar, which remains a reference cultivar, and the oat cultivar AC Rigodon, which was named by *Industry News* as one of the five finalists for the Seed of the Year prize in 2010
- Developed alfalfa cultivars less sensitive to severe winter conditions and diseases, and several cultivars of forage grasses with improved yield and regrowth; these cultivars are widely grown in Eastern Canada
- Developed technologies for intensive mechanical forage conditioning and forced ventilation in order to reduce losses related to the vagaries of the weather
- Conducted pioneering research on the use of lignocellulose biomass for the production of ethanol as part of the Green Plan
- Established that residues from the paper industry are an excellent source of nutritional elements as well as an excellent organic amendment for the improvement of soil
- Developed soil quality indicators that allow the selection of beneficial management practices at the farm level
- Developed a country-specific methodology for the national inventory of soil nitrous oxide (N_2O) emissions that is used by the Government of Canada for international reporting
- Developed mitigation strategies for reducing N_2O emissions and increasing carbon sequestration in soils; these strategies have been translated into recommendations to farmers to help them reduce their environmental footprints
- Developed a fall harvest strategy for alfalfa based on cumulative degree-days rather than calendar dates; This strategy has contributed to changes in recommended management practices that favour better winter survival

- Developed the first model (CATIMO or Canadian Timothy Model) for the growth and nutritive value of timothy in collaboration with the Norwegian Crop Research Institute. The model is now being used to assess the impact of climate change on the yield and nutritive value of Canadian forage crops and to develop a model of forage-based agro-ecosystems
- Developed plant-based indicators of phosphorus and nitrogen deficiencies in forage grasses, corn and wheat; these in-season indicators are used to decrease economic and environmental losses due to excess nitrogen and phosphorus fertilization
- Research on ice encasement and anoxia on the biochemistry and physiology of forage crops in Eastern Canada has identified several factors that have a significant impact on winter survival and spring re-growth, and became the basis for recommendations
- Developed new selection and management strategies to improve the energy and digestibility of forage crops. These strategies have led to specific management practices and recommendations to farmers
- Predicted the impact of climate change on the risks of winter damages to perennial crop species (e.g. alfalfa) using winter-based climatic indices. The predicted increase in air temperature will increase the risks of winter damage to perennial forage crops grown on more than 2 million hectares in Eastern Canada

The Soils and Crops Research and Development Centre in Quebec relies on the expertise of a multidisciplinary team of 23 researchers focusing on crops and agri-environmental issues in order to develop lasting solutions to the complex problems of agricultural production in a rapidly evolving economic and environmental context.

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Normandin Research Farm
Normandin, Quebec

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The Normandin Research Farm was founded in 1936 as the Normandin Experimental Farm to carry out research on the improvement of dairy cattle, swine, sheep, horses, poultry and bees. Later the research focus shifted towards the improvement of several crops adapted to cool climates—notably forage crops, oilseeds (especially canola), lowbush blueberry and small fruits—as well as soil fertility in the context of environmental sustainability, with the aim of contributing to the development of new opportunities for producers both regionally and nationally.

The early years, 1936–1985

The first agricultural trials at Normandin, Quebec were undertaken in 1905 by Alphonse Poirier. In 1936, the federal government purchased two farms in order to establish the Normandin Experimental Farm. The Farm originally occupied 84 hectares, but eventually grew to nearly

145 hectares. Research activities centered on the improvement of dairy stock, swine, sheep, horses, poultry, and bees, with some cereal and forage crop trials also taking place.

Between 1936 and 1985, the focus of research at the Normandin Experimental Farm changed several times. For example, a number of livestock production research projects were transferred or abandoned. Several farm buildings were demolished, leaving only the dairy and crop production buildings. A laboratory with growing-chambers for plants was built, along with a new loafing barn and a silo for the storage of forage crops.

The beginning of the second century of research, 1986–2011

In 1986, when the Normandin Experimental Farm celebrated its 50th anniversary, the scientific personnel consisted of three researchers working on dairy cattle, forage crops and grain farming. At that time, the Farm included 17 buildings.

New Facility

The construction of a new administrative and scientific complex started in 1991. A number of old buildings were demolished to make room for the new structures. The new complex opened in 1992 and the Farm was renamed the Normandin Research Farm in 1993.

The Farm was instrumental in the effort to expand canola production into Quebec. Canola research began in 1987 and producers began growing canola the following year. Farm researchers also developed growing methods suitable for cold and wet conditions.

In the 1990s, the Department implemented a number of research programs in collaboration with industry. The early 1990s saw Canada-Quebec agreements signed. In 1995, the arrival of the Agri-Food R&D Matching Investment Initiative enabled Normandin researchers to conduct several research projects in collaboration with industry.

Research on dairy cattle was consolidated at the Dairy and Swine Research and Development Centre in Sherbrooke, the forage crops quality researcher was relocated to the Soils and Crops Research and Development Centre in Quebec City, and a new researcher was hired to begin a soil research program. Research focus was on the development of management practices for the expansion of canola production in eastern Canada and the establishment of tall fescue as an alternative forage crop on many farms. Additional research was conducted on soil quality and fertility, and on associated environment-related issues, such as more efficient nutrient management.

During the same period, the Farm established the Farm Advisory Committee comprising various regional stakeholders in the agriculture field. The Committee met twice a year to discuss current research projects at Normandin and the needs of producers in the region.

Between 2000 and 2010, research focused on the introduction of new species such as proso millet, reed canary grass, Kura clover, dry beans, flax and lentils to diversify rotations and reduce the incidence of disease. These species are well adapted to the cool, humid climate. Environment-related research focused on the management of nitrogen fertilization of wild lowbush blueberry, barley, and canola in order to adjust fertilization rates to crop needs, improve yield, and minimize the impact of residual nitrates. Finally, the effect of cultural practices on the development of diseases in cereals was investigated. In 2009, the appointment of a new researcher ensured continuity in the forage crop and small fruits research programs. There are currently three researchers at the farm.

Research highlights over the past 25 years

- Demonstrated that soil boron deficiencies in some Quebec regions could be responsible for ergot, which can lead to the downgrading of grain and to nutritional problems when the contaminated grain is eaten by livestock
- Developed new reference values for optimal concentrations of nutrients in wild lowbush blueberry leaves for the Saguenay-Lac-Saint-Jean region to replace the values established in the 1970s

in Maine. These values enable agronomists to adjust and validate fertilization of blueberry fields according to the crop requirements and to avoid over-fertilization and the accumulation of nutrients in the soil

- Demonstrated the production potential for the northern region of broad beans, dry beans, flax, Kura clover, proso millet, orchardgrass, tall fescue, reed canary grass, and Kentucky bluegrass, and developed farming practices
- Demonstrated the hardiness of 450 woody ornamentals species and cultivars as well as the agronomic potential of Saskatoon berry, black chokeberry, highbush cranberry and common elderberry

Field Days

Over the years, the Normandin Research Farm has held numerous open houses, at which producers and members of the general public have been able to learn about current projects. As well, producer groups from a number of Quebec regions regularly come to visit the research plots.

The year 2011 marked the 75th anniversary of the Normandin Research Farm. Throughout its history, the Farm has been able to adapt to the times. Its mission has often changed, but the farm continues to contribute to the advancement of agriculture both regionally and nationally, and to develop new possibilities for farm producers. In addition, with an infrastructure that is on the cutting edge of technology, the Farm is well positioned in terms of both human and material resources.

Dairy and Swine Research and Development Centre
Sherbrooke, Quebec

Jean-Marc Deschênes, Director (1989-1998), Research Branch, Sherbrooke

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Founded in 1914 in Lennoxville, a borough of Sherbrooke since 2002, the Centre has played an important role in the development of agriculture in the Eastern Townships of Quebec. Over the past 25 years, the Dairy and Swine Research and Development Centre, formerly known as the Lennoxville Research Station, has made a major contribution to the improvement of the agricultural animal sector in Canada. Scientific research has been conducted with respect to nutrition, physiology, metabolism, molecular biology, reproduction, breeding and animal welfare in dairy and beef cattle, swine and sheep. These scientific studies were made possible by the recruitment of new researchers as well as the construction of new research facilities, notably the laboratory and office complex (1986), the swine research complex (1999) and the dairy research complex (2010). The Centre continues to work with the Canadian livestock industry in order to develop new knowledge, tools and practices that will increase its competitiveness while protecting the environment.

The early years, 1914–1985

The Dairy and Swine Research and Development Centre was founded in 1914 as the Lennoxville Experimental Station. Eventually it was renamed the Lennoxville Research Station in 1959, which became part of Sherbrooke in 2002. Home to a wide range of plant and animal species, it was conceived as a demonstration facility for the farming community in Quebec's Eastern Townships. Staff was engaged in demonstrating the best-known methods for producing fruits, vegetables, cereals and forage crops, and identifying the most suitable breeds of livestock for the region. As agriculture in the Eastern Townships evolved, the dairy, beef, swine, and sheep industries gradually increased in importance, as did the need for more research in these sectors.

From the mid-1930s to the late 1950s, research at the Centre became more specialized, particularly in the areas of genetics, nutrition and the management of farm animals. During this period, staff also continued to work on adapting and managing forage crops, evaluating cereal varieties, improving the quality of cereals and forage crops, enhancing silage and feed corn production, and improving soil fertility.

From the early 1960s to the mid-1980s, animal research at the Station expanded, increasing the number of researchers from 11 to 23. The goal of animal research, which focused on genetics, reproduction, nutrition, physiology, animal husbandry and animal welfare, was to improve the efficiency of animal production in Quebec. Research on forage crops was aimed at maximizing their utilization by ruminants, while soils research dealt with manure management, fertility and erosion in order to improve soil productivity and reduce soil degradation. Throughout this period, collaboration with universities, the private sector, and the province focused on forming partnerships in order to address the needs of the agriculture sector and develop new technologies.

The beginning of the second century of research, 1986–2011

In September 1986, the Lennoxville Research Station relocated to a new office-laboratory complex. The new facility featured modern scientific equipment and highly specialized laboratories to allow scientists to conduct research using state-of-the-art techniques. A 350-hectare farm provided feed for the Station's livestock and served as a testing ground for ongoing research on forage crops and soils.

People and Programs: 1986

Ninety-five employees worked at Lennoxville including 23 researchers in five research areas:

- Dairy cattle: 10
- Beef cattle: 2
- Swine: 4
- Sheep: 1
- Forage crops: 2
- Soils: 4

In 1989, Lennoxville became responsible for La Pocatière Experimental Farm, where most of the sheep research took place. Science activities were organized into three research programs: milk production, slaughter animals (beef, swine, and sheep), and soil-forage crop management. In 1990, research was re-organized into two animal sections—swine and dairy cattle—to better address the new research mandate assigned to the Centre by Research Branch. Consequently, the soil-forage crop management section was phased out and its researchers reassigned to the swine and dairy cattle sections.

Dairy research included work on the physiology of reproduction and lactation, on nutrition, and on animal behaviour and welfare. Research was also conducted on milk- and grain-fed calves. In 1992, research efforts on reproductive physiology were consolidated with the *Centre de recherche en biologie de la reproduction* at Laval University. A Lennoxville researcher was relocated to the Laval campus for that purpose.

Working with Industry

From 1994 to 2002, the Centre participated in several cost-shared programs with the dairy, beef, swine and sheep industry to further research efforts under the Agri-Food R&D Matching Investment Initiative. As an example, a collaborative project with the Dairy Farmers of Canada and Novalait demonstrated that folic acid and vitamin B12 administered to dairy cows increase the level of B12 in milk. Using pigs as a human model, it was shown that vitamin B12 present in milk is better absorbed than the synthetic form of vitamin B12 used in vitamin supplements.

Swine research looked at sow productivity, carcass quality, molecular probes as selection tools, and the use of mathematical modeling to predict animal performance, nutrition, animal behaviour and welfare, and manure management.

Up to its termination in 1990, the research program on soil and forage crop management focused on the effects of slope, rain intensity, and soil cover on soil erosion, and manure and fertilizer losses, and the effect of forage conditioning and silage on feed digestibility.

The sheep research program focused on improving the reproductive and growth performance of the Dorset-Leicester-Suffolk (DLS) breed, which had been developed in Lennoxville in the mid-1960s, and the lambing behaviour of the prolific Romanov ewe. This Romanov breed had been brought to Lennoxville from France in 1981. In 1989, the Canadian Sheep Breeders' Association officially recognized the DLS breed as a new breed.

The beef research program emphasized beef reproduction through heat synchronization, feed efficiency, and protein supplementation, as well as growth rate and meat quality stemming from forage-based feeding.

The Lennoxville Research Station was renamed the Dairy and Swine Research and Development Centre in 1993 to better reflect its assigned national mandate to conduct research on dairy cattle and swine. In 1993, the Kapuskasing Experimental Farm became the Beef Research Farm and began to report to the Lennoxville Centre.

After the 1994 Program Review, the Centre's national mandate for dairy and swine research was confirmed. Seven scientists from the Centre for Food and Animal Research in Ottawa and one scientist from the La Pocatière Experimental Farm were added to its staff as a result of the closure of these two research establishments in 1997.

Dairy research during this period focused on increasing the efficiency of milk production by improving feed utilization, milk composition and reproductive performance, and by creating stress-free environments for the animals. To facilitate this work, the Centre assembled multidisciplinary teams of researchers with expertise in nutrition and the physiology of digestion, lactation, and reproduction, as well as animal behaviour. A researcher from Lennoxville joined the genetic improvement program for dairy cattle at the University of Guelph in 1997. To ensure sound technology transfer, a position at Lennoxville was created in partnership with the Dairy Farmers of Canada. The objective was to disseminate to Canadian dairy farmers the results of research conducted at the Centre and other dairy research establishments across Canada and abroad. Departmental officials as well as representatives from the dairy and swine industry saw this joint public-private venture as innovative and a best practice. Dissemination of research results to clients thus became a key component of research.

Research on swine concentrated on the factors affecting growth, prolificacy and lactation in the context of animal welfare. It also examined how the utilization and digestion of rations affect the composition of pig manure with the aim of reducing the excretion of nutrients in manure. Management of animal waste had become important due to the growing awareness of environmental considerations with respect to animal production. Lennoxville was an excellent site for conducting such research because of the scientific expertise transferred from Ottawa and the presence of animals. A new program was launched to develop a low-cost, easy-to-operate manure treatment using an anaerobic process. Major investments in equipment—including bioreactors and data acquisition systems—were made in order to measure how well the technology worked with both small and large (commercial or semi-commercial) volumes.

Beginning in 1997, Lennoxville has continued its research support to the sheep industry by providing a researcher to Laval University, and has collaborated on beef research with the Beef Research Farm in Kapuskasing.

Research Partners

Canadian universities:

Alberta, Guelph, Laval, Manitoba, McGill, *Montréal, Université du Québec à Montréal*, Saskatchewan, Sherbrooke, Waterloo

Federal departments:

Health Canada, Environment Canada

Other Canadian collaborators:

Canadian Centre for Swine Improvement, *Centre de développement du porc du Québec,* Prairie Swine Centre, Dairy Farmers of Canada

International collaborators:

Germany: Leibniz Institute of Farm Animal Biology

Australia: University of Sydney

Brazil: Embrapa; universities: Federal de Mato Grosso, Federal de Santa Maria, Estadual de Londrina, Estadual de Sao Paulo, Estadual de Santa Maria, Estadual de Maringa

China: Inner Mongolia University

Denmark: Foulum Research Institute

Spain: Université autonome de Barcelone, IRTA, Université Lleida

United States: U.S. Department of Agriculture (Beltsville); universities: California (Davis), Cornell, Michigan State, Colorado, PennState, West Virginia, New Hamsphire

France: *Institut national de la recherche agronomique* (INRA St-Gilles, Theix, Toulouse, Rennes, St-Genès-Champanelle), *École nationale supérieure agronomique de Toulouse,* IFIP, AgroParisTech

New Zealand: AgResearch

United Kingdom: Royal Veterinary College, Rowett Research Institute, Aberystwyth University

Uruguay: *Université de la Republica*

In 1997, funding was approved for the construction of a new swine research complex, which included barns to accommodate about 450 animals, a small abattoir, laboratories, working areas and modern manure storage facilities. Consultation and an open house took place prior to construction in order to inform the public and obtain feedback. Construction began in 1998, and the official opening took place in September 1999.

After 2000, dairy research in Lennoxville maintained its focus on increasing the efficiency of milk production while ensuring animal welfare, by improving feed utilization, milk composition, reproductive performance and mammary gland metabolism. Of particular interest was research conducted in collaboration with the newly created Atlantic Dairy and Forage Institute Inc. in New Brunswick. The research focused on the nutritional value of flax and its omega-3 fatty acids with respect to reproduction in dairy cows.

In 2004, two researchers who had been conducting research on lodging environment, handling methods and feeding systems in relation to the welfare and behaviour of dairy animals were transferred from Lennoxville to Agassiz to continue their work in collaboration with researchers there and at the University of British Columbia.

Swine research examined the factors affecting prolificacy and lactation in sows, and piglet survival and growth, in the context of animal welfare. As well, it focused on meat quality, precision feeding through modeling, and the impact of diet on the composition of pig manure with the aim of reducing the excretion of nutrients.

In May 2009, the Department announced the modernization of the Centre's dairy research facility. The new 6,000-square-metre facility includes laboratories and service areas, conventional and specialized barns, feed storage areas, preparation and delivery facilities, a milking parlour, and manure storage. Construction started in September 2009 and was completed in September 2010.

The Centre currently conducts research into three areas (dairy, swine, and the environment) in four strategic directions: environmental protection; animal-based food production with high nutritional value and quality; the sustainability of agri-business; and animal welfare.

People and Programs: 2011

The Centre has 140 employees, including 23 researchers, one of whom is working on reproductive physiology in sheep at Laval University, and another who specializes in beef cattle at the *Université du Québec en Abitibi-Témiscamingue*.

- Dairy cattle: 10
- Swine: 8
- Environment: 3
- Beef: 1
- Sheep: 1

The dairy research team works on metabolism and nutrition, including rumen microbiology, the biology of lactation, molecular genetics and reproduction.

The swine research team conducts research in metabolism and nutrition, precision feeding using mathematical modeling, the biology of lactation, immunology, molecular genetics, animal welfare and meat quality.

The environment research team works on the reduction of gas emissions and biological contaminants from animal production operations, the treatment and valorization of agricultural and agri-food wastes, and the production of alternative sources of renewable energy. Research also includes developing methods to quantify and reduce the greenhouse gas emissions produced by livestock, manure pits, and farm buildings.

Research highlights over the past 25 years

Dairy

- Improved cattle diet to maximize nitrogen utilization and minimize nitrogen excretion
- Revised the vitamin-B-complex needs of dairy cattle, based on optimal metabolic efficacy

- Developed a new method to combat the antibiotic-resistant bacteria that cause mastitis
- Demonstrated the nutritional value of flax and its omega-3 fatty acids for dairy cattle reproduction
- Determined the beneficial effect of carbohydrates present in forages on feed intake and on the production and composition of milk
- Reduced cross-sucking between calves reared in groups by providing a non-nutritive teat to calves after their milk meal; well-being, health and growth were thus improved
- Increased the duration of light exposure from 8 to 16 hours per day during lactation to influence mammary gland development and increase milk yield
- Recommended sustained weight gain per day, rather than accelerated weight gain, in heifers between the age of 12 and 24 months to maximize mammary growth, minimize reproductive problems and optimize milk production during first lactation
- Identified a new strain of rumen bacteria that digests fibre more efficiently
- Identified a plant extract (essential oil) that helps improve the efficiency of feed utilization and reduce methane production
- Developed a sustainable nutrition strategy for raising calves

Swine

- Carried out research on B-complex vitamins that led to supplementing commercial feed with folic acid to maximize sow reproductive performance; this had a large impact on production efficiency
- Improved methods to determine nutritional requirements and feeding management for pigs, and consequently improved ways to formulate diet

- Developed new systems to evaluate carcasses
- Created Porc-Expert software in collaboration with Laval University for the evaluation of feeding regime strategies, genetic traits and management conditions in order to predict effects on animal performance and profitability; the software is used widely by the industry
- Formulated a new feeding management strategy specific to young sows in order to maximize mammary gland development and milk production
- Determined that administering probiotics to piglets contributes to the reduced use of antibiotics to control *E. coli* infection
- Developed a precise test to detect the genetic mutation responsible for PSE (pale, soft and exudative) meat in various pig tissues; testing of pigs in Quebec was conducted in collaboration with the *Fédération des producteurs de porcs du Québec* and led to the elimination of carriers of the defective gene, which had a major impact on the ability to meet requirements for exporting pork to Japan

Environment

- Developed a low-temperature anaerobic digestion technology that significantly reduces the odour, organic contaminants and volume of agricultural wastes. It also produces bio-energy while maintaining the fertilizing properties of manure. The process was tested in commercial bioreactors and is currently being used on a few pig farms

The Dairy and Swine Research and Development Centre continues to work with the Canadian livestock industry to develop new knowledge, tools and practices that will increase its competitiveness and protect the environment. Special emphasis will be placed on reducing the environmental impact of livestock production. This will involve greater integration of the work done to improve growth, reproduction performance, health, and lactation through research in nutrition, physiology, metabolism, molecular genetics, mathematical modeling, feed formulations and precision feeding, as well as environmental issues like greenhouse gas emission, energy efficiency and diffuse pollution.

At the same time, researchers are working on ways for industry to improve feed and manure management to limit agriculture wastes, reduce odours and contaminants, and produce bio-energy through manure treatment.

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Sheep Research Farm
La Pocatière, Quebec

Jean-Marc Deschênes, Director (1989-1998), Research Branch, Sherbrooke

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In 1910, the first experimental farm in Quebec was established in La Pocatière. From 1986 to 1997, La Pocatière Experimental Farm focused its research on sheep production and potato breeding. La Pocatière's potato breeding program made the rapid multiplication of seed potatoes possible, and significantly reduced the time to develop a cultivar. The sheep research on nutrition, the genetic traits of hybrid and purebred ewes, hormonal treatment, and on the environment contributed to an increase in the prolificacy of ewes and the meat quality of lambs. After the Farm's closure in 1997, its sheep flock, facilities and equipment were transferred to not-for-profit organizations. Ongoing collaborative research between the new organizations and the Dairy and Swine Research and Development Centre in Lennoxville (now Sherbrooke) as well as Laval University is ensuring that the needs of the regional agricultural sector continue to be met.

The early years, 1910–1986

La Pocatière Experimental Farm was the first federal experimental farm in Quebec. Established in 1910, the Farm's original purpose was to serve as a demonstration farm for the Lower St. Lawrence region. From 1910 to 1921, research focused on the evaluation of fruit trees, the introduction and improvement of farm livestock, and the cultural practices and production costs associated with cereals, forage crops, vegetables and sugar beets.

From 1922 to 1945, increased emphasis was placed on dairy research and animal feed production while work continued on swine, sheep and poultry production and adaptation testing of cereals, forages and pulse crops. The potato research program began in 1940 with variety trials, a breeding component being added in 1979. From 1946 to 1959, emphasis was placed on breeding and managing forage crops, cereals and herbicide evaluations, as well as on genetic improvement of dairy cattle and sheep.

Several researchers left the Farm in the 1960s, mainly to join the new Faculty of Agriculture at Laval University. Nonetheless, the Farm maintained its pace of scientific achievement, notably in the areas of cereal and potato breeding, pesticide and cultivar evaluation, and sheep and dairy cattle improvement.

From 1971 to 1985, the Farm's mandate focused on cultivar and herbicide evaluation as well as the management of forage crops, cereals and potatoes. In addition, sheep breeding in collaboration with the research station in Lennoxville was strengthened, resulting in the development of the renowned Dorset-Leicester-Suffolk (DLS) breed. The construction of a new office-laboratory was completed in 1985. Major renovations of the service building (cereals, forage crops, potato) were initiated in 1986 and completed in 1987.

The beginning of the second century of research, 1986–1997

In 1986, the sheep breeding and potato breeding programs were the main focus of research. Researchers were also evaluating forage crop cultivars as part of the Quebec testing network, testing herbicides and assessing fruit trees—notably prunes and pears—and woody ornamentals. The Farm reported to the Director of the Sainte-Foy Research Station (Quebec).

People and Programs: 1986

La Pocatière Experimental Farm covered 260 hectares and had 31 employees, including a superintendent and three researchers, conducting research in potato breeding, sheep breeding, forage crop management, and cultivar and herbicide evaluation.

The evaluation of fruit trees (mainly prunes and pears) and woody ornamentals came to an end in 1988, as did the potato breeding program in 1992. At the same time, sheep research was strengthened, having been discontinued in all other federal establishments.

The sheep program was considerably revitalized with the construction of a modern sheep barn complex in 1987. The barn was completely destroyed by fire in October 1989, significantly limiting the sheep research effort for a few years. Nevertheless, a minimum level of research was maintained in collaboration with the Lennoxville Research Station and provincial sheep producers until the sheep barn complex could be rebuilt in 1993.

A strategic planning meeting was held in the early 1990s involving departmental representatives as well as representatives of all provincial agriculture departments and sheep producer organizations. Research priorities were identified, including finishing sheep raised on pastures, improving the utilization of fat and protein, and flock management and reproduction. In order to address these priorities, sheep research concentrated on the reproductive performance of prolific and non-prolific breeds, the effect of high-protein diets on carcass quality and the lambing behaviour of prolific and non-prolific ewes, and the effect (improved reproductive performance) of the F gene on hybrid ewes carrying the gene, as compared to purebreds.

Research on forage crops (e.g. cultivar evaluation, legume establishment) was conducted in support of the sheep research program.

In 1989, responsibility for the Farm was transferred from the Sainte-Foy Research Station to the Lennoxville Research Station, which had a mandate for animal-production research. The Farm was renamed the Sheep Research Farm in 1993.

Subsequent to Program Review in 1994, closure of the Farm was announced. In 1997, the Farm's installations, sheep flock and equipment were transferred to the *Centre de développement bioalimentaire du Québec* (CDBQ). During these transition years, research continued on sheep reproduction, nutrition and management, as well as forage crop management in support of sheep research.

Intensive discussions took place in an effort to protect valuable assets and to ensure that all legal, safety and correctives measures were addressed before transferring the Farm and its installations to the private sector. Key actions included an agreement in 1995 with Laval University for the continuation of the evaluation and registration of La Pocatière's potato lines, and for the creation of the *Centre d'expertise en production ovine du Québec* (CEPOQ). An agreement was reached between the Dairy and Swine Research and Development Centre in Lennoxville, the CDBQ, the CEPOQ and Laval University to allow use of the sheep barn complex and the sheep flock. As well, it was agreed that, in collaboration with the Quebec sheep industry, a new healthy sheep flock (Dorset, Suffolk, Romanov) would be reconstituted—one with desirable traits, so that any risk of the presence of undesirable diseases would be eliminated.

People and Programs: 1995

La Pocatière Research Farm had 600 head of sheep, and a staff of 32, including five researchers working in sheep reproduction, nutrition and management, and forage crops management in support of sheep research.

Assuming control of the Farm, CDBQ signed an agreement with CEPOQ for use of the sheep flock as well as the sheep barn complex and equipment. In 1997, the sheep reproduction researcher was posted to the Department of Animal Science at Laval University to work on sheep reproduction in collaboration with reproduction researchers there and at CEPOQ.

Research Partners

- Dairy and Swine Research and Development Centre (Lennoxville)
- *Ministère de l'Agriculture des Pêcheries et de l'Alimentation du Québec*
- Laval University
- *Fédération des producteurs de moutons du Québec*

The closure of La Pocatière Research Farm in 1997 saw the end of several decades of agricultural research achievements and impacts for the region. However, the transfer of the Farm and its installations and equipment to other organizations, as well as the collaborative research with the Dairy and Swine Research and Development Centre at Lennoxville and Laval University, ensured that the regional agricultural sector continued to be well served.

Research highlights between 1986 and 1997

Sheep

- Demonstrated that the photoperiod synchronized the reproduction cycle
- Determined that the F gene increased ovulation rates and litter sizes in hybrid ewes carrying the gene (as compared to purebreds), but also increased perinatal mortality, so that no gain in overall productivity was achieved.
- Demonstrated that ewes fed with a protein supplement lost less weight during lactation and produced more milk

- Found that Romanov/Dorset lambs showed a higher weight gain and lower back fat than Romanov/Suffolk lambs
- Showed that adding fish meal to lamb diets improved carcass quality

Potato

- Developed a technique for rapid multiplication of seed potato by propagating from stems and sprouts, thereby significantly reducing the time needed to develop a new cultivar
- Issued the Mouraska potato variety from La Pocatière's potato breeding program

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Beef Research Farm
Kapuskasing, Ontario

Jean-Marc Deschênes, Director (1989-1998), Research Branch, Sherbrooke

The Beef Research Farm (formerly known as the Kapuskasing Experimental Farm, created in 1914) conducts research on reproduction and new beef production methods, including the production and conservation of grasses used as feed for beef in northern Ontario and Quebec. The unique climatic and environmental conditions of these areas, together with the vision, commitment and dynamism of regional agricultural organizations and communities, have made profitable beef production possible, based on a high quality grass feeding system.

The early years, 1914–1985

The Kapuskasing Experimental Farm officially began operation in 1914 as a First World War prison camp. It later became a shared facility of the military and the Department of Agriculture for supporting agricultural development in the Great Clay Belt of northeastern Ontario and northwestern Quebec. The research priorities then were soil fertility as well as crop and livestock management to help farmers survive in the challenging northern environment. In the early years, research focused on goats, pigs, chickens and dairy cows, as well as a variety of crops, notably cereals, grasses and vegetables.

For seven decades, research and innovation at Kapuskasing led to significant achievements in forage production, conservation and use, in cereal and horticultural crop production, as well as in beef cattle nutrition, management, breeding and reproduction. Of particular interest was research related to intensive grass production and to high-humidity grass silage production. This research led to the development of heap silos as well as to beef production using only high-quality grass silage.

In later years, collaborative research on beef cattle was conducted with colleagues from universities and the Animal Research Institute in Ottawa, notably on the importance of the quality of protein and energy needed for ruminant productivity. Forage and cereal crop research conducted in Kapuskasing supported the work of the Ontario and Quebec provincial crop committees, whose mandate at the time was to evaluate and recommend the crops and varieties best adapted to the region. Research was also carried out on forage production management in support of ruminant productivity, and on cereal cultural practices in relation to short-season growing areas.

The beginning of the second century of research, 1986–2011

During this period, the Kapuskasing Experimental Farm pursued its mandate to conduct research on new beef production methods, and to evaluate and manage forage, cereal and horticultural crops for northern Ontario and northwestern Quebec. Much of this research was conducted with researchers from the Animal Research Centre and the Plant Research Centre in Ottawa. In 1986, the Farm reported directly to the Director General of Ontario Region, and was responsible for the management of the Thunder Bay Experimental Farm.

Thunder Bay Experimental Farm

Thunder Bay Experimental Farm was opened in 1937 to conduct research on the adaptation of cereal and forage crops, and the multiplication and assessment of potatoes. This facility produced seed potatoes for evaluation in the Ontario regional trials, and selected tubers from breeding lines developed by the Department's breeder located at the University of Guelph, in order to conduct advanced planting tests. Kapuskasing remained responsible for the Thunder Bay Experimental Farm until its transfer to the Harrow Research Station in 1994. The Farm's closure was announced as part of the 1994 Program Review.

In 1986, the two researchers recruited by the Sainte-Foy Research Station and seconded to the *Ministère de l'agriculture, des pêcheries et de l'alimentation du Québec* (MAPAQ) (and later to the *Université du Québec en Abitibi-Témiscamingue* (UQAT) in Rouyn-Noranda) began research on the evaluation and management of forage, cereal and horticultural crops for northwestern Quebec. The research took place on a leased experimental site in Evain, near Rouyn-Noranda, and in Kapuskasing. Cultivars of legumes, grasses and cereals recommended for Quebec were established in order to evaluate their performance under the climatic and soil conditions of the Abitibi-Témiscamingue region. These trials were conducted in collaboration with the *Conseil de recherche en agroalimentaire de l'Abitibi-Témiscamingue*, which received financial support from the Market and Industry Services Branch. Ensilability (the capacity of a plant to ferment) and silage conservation became a problem with the elimination of formic acid as a conservation agent. In 1987, the two biologists began reporting to Kapuskasing in lieu of Sainte-Foy. In 1989, a biologist was recruited to work on ruminant nutrition. Research in the 1990s focused on forage crop management to increase ensilability and define criteria for better use of preservatives, notably lactic inoculants.

People and Programs: 1986

The Kapuskasing Experimental Farm had 32 employees including two researchers, one working in the areas of forage and cereal crops and the other carrying out beef research. The Farm possesses 370 hectares of land and 300 head of beef cattle.

Kapuskasing began to report to the Dairy and Swine Research and Development Centre in Lennoxville (now Sherbrooke) in 1993, after having been autonomous in the Ontario Region for many years. It maintained its focus on beef production, and that same year, the facility was renamed the Beef Research Farm to better reflect the new research mandate assigned by Research Branch.

The 1994 Program Review resulted in a 50 percent reduction in the workforce at Kapuskasing, including the phasing out of one researcher in Rouyn-Noranda, the ending of cultivar evaluation and the reduction of the beef herd. By the end of 1997, the Farm had 14 employees including two researchers.

The Farm's mandate was to develop new management techniques and methods of beef cattle management and reproduction, as well as forage conservation and uses, in order to increase the profitability of beef production in Eastern Canada. The main objective was to develop a beef production system for northern regions, using the existing resources and scientific expertise of the Kapuskasing and Rouyn-Noranda facilities, along with those of the Dairy and Swine Research and Development Centre in Sherbrooke, the New Liskeard campus of the University of Guelph, and the local beef industry.

Research Partners

- Dairy and Swine Research and Development Centre (Sherbrooke)
- Food Research and Development Centre (Saint-Hyacinthe)
- Market and Industry Services Branch
- *Conseil de recherche en agroalimentaire de l'Abitibi*-Témiscamingue
- *Université du Québec en Abitibi-Témiscamingue*
- *Ministère de l'Agriculture des Pêcheries et de l'Alimentation du Québec*
- Laval University
- University of Guelph

For the past decade, researchers at Kapuskasing have been conducting beef research that is unique in Canada, well adapted to northern Ontario and northwestern Quebec, and transferable to other northern regions of Canada. For example, the Golden Beef project was designed to produce leaner beef calves by feeding them with mother's milk and locally grown, high-quality forages without additives such as antibiotics. The focus has been on changing the fats in the muscle tissues into good fats, such as omega-3s, and on producing a niche-market animal with higher quality, leaner meat that can be sent to slaughter earlier. The project also tackles the conservation of forage silage fed to beef cattle, beef herd management to improve the performance of forage-fed beef, environment protection through improved manure management, and pasture management to improve productivity and meat quality.

In the early years of the Golden Beef project, the researcher posted in Rouyn-Noranda collaborated with departmental researchers in Sherbrooke and Saint-Hyacinthe, as well as with researchers at Laval, UQAT and Guelph University. Since 2007, this project has been pursued in collaboration with departmental and Guelph University researchers.

People and Programs: 2011

The Beef Research Farm in Kapuskasing had 18 employees, including one researcher in Rouyn-Noranda and 120 head of beef cattle. The staff carried out research on forages and on the management of forage-fed beef.

Research highlights over the past 25 years

Beef

- Developed a practical method to provoke heat in beef cattle by administrating a hormone treatment and inseminating the animal within a prescribed time following the treatment; this considerably reduces the need to detect heat while maintaining fertility, and contributes to the increased use of artificial insemination in beef herds
- Demonstrated that young beef calves fed mother's milk and high-quality grasses stored as silage and served to animals without additives such as antibiotics, produced carcasses with leaner meat and better fats (improved ratio of omega-3s to omega-6s); these animals reach market size at a younger age than beef produced using a conventional forage and grain based system
- Discovered that adding protein supplements to silage increased feed efficiency, growth rate and weight gain in growing steers
- Determined that feeding pregnant cows in winter with only late-cut silage fermented without preservatives increased the incidence of congenital joint laxity and dwarfism but that supplementing silage with hay and barley eliminated these problems
- Contributed to the understanding of ovarian physiology, resulting in improved embryo production and the transfer of frozen embryos with pre-determined sex

- Developed new beef production practices that have opened new opportunities to northern producers by allowing them to profit from the northern region's high forage-production potential

Forage evaluation and conservation

- Demonstrated that alfalfa performed better than other legumes in forage mixtures (grass-legume) but that grasses generally become dominant two years after establishment
- Refined the Acid Detergent Fibre-based equation that predicts the metabolic energy of forages and thus helps reduce feed costs
- Showed that adapting the mole-drain technique to heavy clay soils significantly contributed to yield increase in cereals and grasses by controlling water level below 40 centimetres from the soil surface and promoting root development. The mole plough, when dragged underground, leaves a channel that acts as a drain that can last from three to five years; this discovery has led to new production practices in a region where drainage was non-existent

The unique climatic and environmental conditions of the northern region of Quebec and Ontario, together with the vision, the commitment and the dynamism of regional agricultural organizations and communities, allow profitable beef production based on a high-quality grass feeding system. Past and current research achievements at the Beef Research Farm in Kapuskasing have contributed to this success and are continuing to do so with existing scientific expertise, resources, facilities and ongoing scientific collaborations.

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Food Research and Development Centre
Saint-Hyacinthe, Quebec

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During the Department of Agriculture's first century of research, almost all of its agri-food research focused on agricultural production. However, the past 25 years have seen a shift toward value-added production and food processing. The Food Research and Development Centre was created in 1987. It was known at that time as the Saint-Hyacinthe Food Research Centre and had a mandate to enhance food industry competitiveness. An active participant in industry collaboration, the Centre focuses on food safety, food quality and improving the health benefits of food. Despite its young age, the Centre has numerous achievements to its credit, with dynamic programs and an original governance structure contributing to its success.

The beginning of the second century of research, 1987–2011

The Saint-Hyacinthe Food Research Centre was opened in 1987, and was renamed the Food Research and Development Centre two years later. The Centre's mandate was to foster interaction with the community and to enhance food industry competitiveness and technology transfer by conducting research on dairy products, plant products, meat products, biotechnology, flavours, and food engineering.

Research activities were supported either entirely with federal funding, or jointly with industry, or entirely by industry, as part of an initiative called the Industrial Program. This unique program met the needs of industry by providing access to pilot plants and by monitoring tests and projects, and through technological assistance, enabling industry stakeholders to complete their own pre-feasibility and other projects. A rate scale for services covered by the Industrial Program—the only one of its kind among the research centres—was published in the *Canada Gazette* in April 1992, and again in December 1994.

The Centre created the Research Centre Governors Council, an advisory committee with a mandate to help align research themes with the priorities identified by the food and beverage processing sectors. The membership was made up of respected members of the agri-food community, mainly individuals from the private sector and academia.

From the outset, the Centre focused on the commercialization of research results and the protection of intellectual property, by encouraging its researchers to submit invention disclosures upon completion of research done internally or in partnership. In 1989, the first invention disclosure was submitted. In the area of food safety, researchers focused on controlling *Listeria*. The first safety tests were conducted in collaboration with the laboratory of the Canadian Food Inspection Agency in the early 1990s. In 1997, the Food Research and Development Centre negotiated the licensing of its technology for the first time. Approximately 30 licenses have been negotiated with roughly the same number of companies.

At the end of the 1990s, the Centre launched its first spin-off company, Colarôme Inc., which was formed in order to exploit a technology for producing natural food pigment from red cabbage extracts.

In addition to conducting its strategic research and industrial program, the Centre organized international symposia. In August 1991, the Centre coordinated its first international event, the XVIII International Congress of Refrigeration, being held in Canada for the first time. The Centre organized the International Symposium on Probiotics, presented every other year in collaboration with the Institute of Nutraceuticals and Functional Foods at Laval University.

People and Programs: 1987

- A staff of 130 employees, including 18 researchers
- New labs and office building
- Industrial Program
- 3,200 square metres of pilot plants for food processing

After 10 years of existence, beginning in 1997, the Centre consolidated its research direction. There had been substantial changes in the technologies used in food processing; some were already in use, including the ultrafiltration of cheese whey, the creation of modified atmospheres to enhance fruit shelf life, sensory analysis, and strategies for producing starter cultures and enzymes. Researchers also explored new technologies, such as the use of spectrometry for vegetable traceability, polymerase chain reaction to detect micro-organisms, high pressure and ohmic heating to preserve food, electro-dialysis to purify ingredients and stabilize juices, and bacteria- or enzyme-encapsulation to improve stability and effectiveness.

Because government-industry collaboration was well entrenched at the Centre, the Agri-Food R&D Matching Investment Initiative (MII) was a success. In 1999-2000, under the MII, close to $3.5 million were invested jointly in research driven by industry priorities.

Role of INITIA

The Research Centre Governors Council created a non-profit organization called the Food Research and Development Centre's Governors Foundation, later known as INITIA, which acted as a bridge between the Centre and scientific entrepreneurs in the agri-food industry. By working with industry and helping the Centre achieve its mission, INITIA has had a leveraging effect and played a key role in the success of the Centre. Besides industry and health professionals, the Centre–INITIA scientific collaboration benefited from the efforts of Canadian and international researchers, students, post-doctoral researchers, veterinarians, agrologists, the media and the public. In the 1990s, under the guidance of the Research Centre Governors Council, the federal government extended the facilities of the research centre with the addition of an industry pavilion housing a large meeting room and a library. In 2002, an industry-incubator called the Food Technology Innovation Centre was added.

The Centre earned an international reputation with the aid of its industry newsletter, *Alimentech*, which it began distributing to its network of contacts in some 80 countries in 1988. Being responsible for the *International Francophonie* program for several years, the Centre also helped bring together stakeholders from francophone countries that were interested in food science and technology. These exchanges enabled the Centre to promote trade missions and knowledge transfer.

In the early 2000s, the Food Research and Development Centre focused on research related to food safety and quality, in keeping with Agriculture and Agri-Food Canada's newly created national programs. This research included expansion into the new areas of pathogenic bacteria (*Listeria, Clostridium, Campylobacter*) and viruses (hepatitis, norovirus), for which the Centre acquired its own level-2 confinement facilities in 2007. The Centre continued its work on food quality, focusing on shelf life, texture, appearance, aromas, and flavours. A new priority has been added, namely increases in the health benefits of food. In the dairy sector, researchers began investigating goat's milk and specialty cheeses. Legumes were added to fruits and vegetables in the plant products sector, and a broad range of grains were examined in the baked goods sector. Researchers developed *in vitro* systems for simulating the stomach and duodenum, analyzed food allergens, eliminated anti-nutritional factors and developed bioactive ingredients and the technologies to add those benefits to foods.

Since 1987, inventions have generated significant royalties for licensed technologies, including revenues from copyright licenses. The Industrial Program has also been a success, with a multitude of industry projects—implemented by more than 1,000 companies—generating substantial revenues as well. The Centre has shared its scientific expertise through in-house research projects, very productive partnerships with the food industry, conferences, seminars and symposia.

Research highlights over the past 24 years

- About 1,000 companies have participated in the Industrial Program over the years, carrying out 1,950 research and development projects. A total of 4,080 industrial requests have been processed by the retrieval and analysis information service since its creation in 1996. Finally, nine companies have used the industrial incubators, two of which commenced successful commercial operations thereafter
- The scientific and technical understanding of milk processing and cheese manufacturing was vital to the success of the Canadian dairy sector's implementation of novel filtration technologies that enhance milk quality, to the continued improvement of manufacturing processes for higher cheese and yogurt quality, and to the marketing of dairy products with health enhancing properties (e.g. calcium-enriched, low-fat)
- Unique fermentation processes were developed that enable the production of novel, appealing and shelf-stable vegetable products. The technology was licensed to a Canadian company that later succeeded in marketing high-quality sauerkraut internationally
- A novel process was developed to extract and purify natural

food colourants from plants as a substitute for chemically synthetized colourants. A spin-off company was created under the name Colarôme

- A unique fruit dehydration system was developed that helped Canada break into the U.S. market for dried cranberry products
- Novel and rapid methods were developed to detect pathogenic viruses in food. These methods have been accepted by Health Canada, and are now used by the Canadian Food Inspection Agency for the routine detection of viruses in Canadian and imported products
- A suite of scientific tools for characterizing maple syrup for enhanced marketing was developed. The wheel of flavours, a user-friendly graphical tool, enabled fine characterization and description of the subtle flavours in maple syrup, and a prototype was developed for instant detection of product adulteration

The Food Research and Development Centre in Saint-Hyacinthe can count on a highly qualified technical and professional staff of 22 researchers to produce international-caliber research. Its principal objective is to develop scientific knowledge and technologies that will enable Canadian food processors to develop and market innovative food products that satisfy consumer expectations. Food safety, which is conducted in collaboration with the University of Montreal's Faculty of Veterinary Medicine and the Canadian Food Inspection Agency is also a key area of research. The Centre is involved in food and health research, investigating technologies for incorporating bioactive ingredients into food while preserving their health-enhancing properties. In addition, the Centre's Industrial Program allows industry members access to a world-class pilot food-processing infrastructure.

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Horticulture Research and Development Centre Saint-Jean-sur-Richelieu, Quebec

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The Horticulture Research and Development Centre, formerly known as the Saint-Jean Research Station, has always had a horticultural focus. It was founded in 1912 in a small laboratory located in Covey Hill, Quebec, south of Montreal, with an entomologist studying insect pests in apple orchards. The Station's growth in its first 30 years was slow, until the team relocated to Saint-Jean-sur-Richelieu in 1940, after which the number of employees increased as horticultural crops grew in importance in the area south of Montreal. This led to the construction of new buildings in 1952 and 1985, and the Station's transformation into a modern research centre for horticulture. The Centre currently has 109 employees devoted to research on the sustainable production of fruits and vegetables with high nutrition and economic value.

The early years, 1912–1985

In 1912, the federal Department of Agriculture established a mobile, portable laboratory in Covey Hill, Quebec, 60 kilometres south of Montreal.

It was transportable on a horse-drawn cart, so that the biology of insect pests could be studied on-site in the orchards. After two years, the laboratory was relocated to the nearby village of Hemmingford and its mandate was expanded to include the control of vegetable insects. In 1940, the laboratory was relocated to Saint-Jean-sur-Richelieu. The two on-site entomologists focused on crops intended for canneries and on plant resistance to insects.

In 1950, new entomology and phytopathology researchers were hired, and in 1952, a new laboratory was built. Now established in suitable premises and with all the equipment needed for research, the staff continued their work on plant resistance to pea and potato aphids, and on the biology of controlling aphids, onion maggots, corn borers, plum curculios, carrot weevils, redbanded leaf rollers and European red mites. Researchers also looked at the impact of pesticide use on mature predators, the epidemiology of apple scab and bacterial blight, vegetable diseases, chemical control, and plant resistance to disease.

In 1962, the research laboratory became the Saint-Jean Research Station and acquired the Ste-Clotilde Experimental Farm, where staff could conduct muck soil research on carrot, onion, celery and lettuce crops. In 1964, the Station bought L'Acadie Experimental Farm to pursue research on corn, crucifers and cannery crops in mineral soil. In 1969, the Station acquired the Frelighsburg Experimental Farm, whose land was optimal for growing tree fruits and small fruits. In 1978, the Station was made responsible for L'Assomption Experimental Farm and the associated Lavaltrie Farm, which focused mainly on tobacco growing.

In the early 1980s, the Station hired staff for production and enhancement of horticulture crops, and research into the protection of fruit and vegetable productions. The Station's current facility opened in June 1985 on the site of the previous building.

The beginning of the second century of research, 1986–2011

In 1986, the Saint-Jean-sur-Richelieu Research Station had 25 researchers divided into three sections: fruits, vegetables, and engineering and soil.

From 1986 to 1996, fruit research focused on the effects of spring frosts on apple trees, the use of the Multi-pher® trap (a pheromone-based trap) in apple orchards, raspberry management, fumigation for controlling raspberry root-lesion nematodes, and the testing of cultivars and selections of blueberry bushes. Research was conducted on new cropping practices for producing strawberries with plant mulches, the winter protection of strawberry plants, the effects of insecticide treatments against apple sawfly, and on the selection of cultivars resistant to apple scab. It also became possible to control the two-spotted spider mites and red spider mites that infest apple orchards, using *Neoseiulus (Amblyseius) fallacis*, a predatory mite raised in a greenhouse.

During this time, vegetable research focused on genetically improving cabbage resistance to clubroot, on the evolution of diseases of stored winter cabbage, and on predicting the appearance of the onion maggot using degree-days. Work was also done on the effect of fertigation solution composition on celery grown in multi-cells, on the construction of a detailed genetic map of cabbages using DNA markers, and on identifying the differences between garlic cultivars using DNA markers.

The Station contributed to the establishment of a genome library of the Colorado potato beetle, and conducted research on the time required for the development of the root-knot nematode in organic soil, the effect of dosage and source of nitrogen on trace-mineral nutrition, the occurrence of hollow heart in broccoli, and on the irrigation method and urea content of the fertilizer solution for vegetable plants. Soya and canola cultivars were assessed, an inventory of canola insect pests was completed, and studies were conducted on the impact of five cropping methods on grain corn and the corn borer.

Engineering and soil research focused on building a controlled-atmosphere storage system for experimental purposes, as well as a low-cost fluid ice system for pre-chilling vegetables. In addition, researchers designed and assessed a pesticide dosage and blending device for experimental plots. A family of standard, reusable containers was developed specifically for improving the treatment and handling of horticultural products and for better preserving their quality.

Cooperation with CIDA

From 1985 to 1995, the Station staff managed a Canadian International Development Agency (CIDA) project in Burkina Faso. The objective of the project was to reduce losses in food crops by setting up a local centre for training and integrating plant protection researchers and technicians. Under the $15-million project, a number of Saint-Jean researchers and technicians trained the local staff and supervised the research projects carried out on site.

In 1994, the Station became the Horticulture Research and Development Centre, specializing in field-grown vegetable crops, but also devoted to meeting specific regional needs for other crops. In 1997, its farm at L'Assomption, Quebec (known as a Research Farm) and its research field site at Lavaltrie were closed. At the same time, the new Agri-Food R&D Matching Investment Initiative enabled the Centre to work in collaboration with industry. Over the years, researchers carried out nearly 240 research and development projects, each lasting from one to three years. Projects dealt with integrated pest management, precision agriculture in horticultural production, bio-pesticides, and the development of harvesters and leading edge postharvest technologies.

After 2002, the Centre's research program focused on the national mandate. Due to its geographic location in the middle of the St. Lawrence Plain, the nature of its expertise and the number and quality of its researchers, the Centre was strategically positioned for studying vegetable and fruit production systems that make use of low-input sustainable production, minimize impact on the environment and capitalize on the improved quality of crops both before and after harvesting. Co-operation with universities was very significant, and enabled researchers to maintain a link with the academic community by conducting research projects further upstream and assisting in the training of master's and doctoral students. The Centre also worked with colleagues from research centres and universities across North America, and in South America, Europe, Africa, and Asia.

In 2002, the Centre was asked to contribute to the Minor Use Pesticides Program to provide producers with better access to minor use pesticides with reduced risks for health and the environment. Between 2002 and 2010, their work resulted in 295 tests with 70 insecticides, fungicides, and herbicides on more than 50 horticultural crops. The results were presented to the Pest Management Regulatory Agency, and 31 pesticides labels were subsequently changed to allow them to be used in new horticultural crops.

In 2011, the Horticulture Research and Development Centre in Saint-Jean-sur-Richelieu had 109 employees, including 19 researchers, devoted to research on the production of vegetables and fruits with high nutrition and economic value.

Research highlights over the past 25 years

- Showed that it is easy to control small bur-marigold (*Bidens Aristosa*), also known as beggar tick by practicing pre-sowing cultivation at the beginning of the season to destroy the bur-marigold seedlings (the seeds produced in a given year germinate early in the following spring), and by delaying the sowing of carrots in organic soil
- Demonstrated that the introduction of pearl millet as a rotation crop helps manage the population densities of root-lesion nematodes in potatoes, which increases potato yields as effectively as soil fumigation
- Created the Agricultural Pest Forecasting software application, which helps reduce the number of pesticide applications
- Improved the insecticide potential of various strains of the *Bacillus thuringiensis* bacteria; four strains with increased toxicity were obtained
- Screened new strains of *Bacillus thuringiensis* to identify isolates with new insecticide, nematicide, molluscicide and cytocide (against certain cancer cells in humans) properties. This research contributed to the development and registration of six bio-insecticides for agriculture, forestry and domestic uses

- Launched a genetic improvement program in 1997 in order to produce a new variety of head lettuce that is more tolerant to the diseases associated with resistance to heat stress, and is better adapted to the processing and export markets. The results led to the registration of two new varieties, Estival and Hochelaga, in 2003
- Developed unique software and databases needed to accelerate the genetic enhancement program for strawberries, raspberries and apples
- Registered two new strawberry cultivars, Chambly and Joliette, in partnership with researchers from Macdonald College, and designated the scab-resistant apple variety, Richelieu. The Oka strawberry plant cultivar was designated in 1991
- Pioneered the RÉCUPAIR method for spraying orchards and vines to distribute spray in an optimal way on the crop and recover most of the spray that would have otherwise been lost
- Developed the Richesse cabbage cultivar, which was resistant to clubroot, and three other resistant cabbage cultivars Châteauguay, L'Acadie and Richelain
- Developed better detection of the apple maggot in orchards using a Ladd-type trap in the shape of a red ball rather than the Pherocon trap that was used at that time in Quebec; these traps use various baits to attract apple maggot
- In partnership with Laval University, developed a method for producing lettuce transplants in cubic plugs that has completely replaced production in multi-cells and provides superior yields and quality
- Carried out research on the uniform flow of air, ice and water in a porous environment, which led to the design of a reusable, recyclable plastic container with openings in the bottom and walls for handling horticultural products (the Smart Crate). Research performed by the University of California at Davis showed that this handling system

reduced postharvest losses of horticultural products by 15 percent; the use of these containers also reduces the amount of cardboard needed to handle horticultural products

Reaching its 100-year anniversary in 2012, the Horticulture Research and Development Centre now focuses its research on the various aspects of production and on reducing the environmental impact of horticultural production in Canada. Researchers specialize in market garden crops, tree fruits, small fruits and new crops, and focus on ways to develop and transfer knowledge, and to produce environmentally-friendly technologies and innovative products.

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L'Assomption Research Farm
L'Assomption, Quebec

Roger Chagnon, Research Manager, Research Branch, Saint-Jean-sur-Richelieu

L'Assomption Experimental Station (later renamed L'Assomption Experimental Farm) was established in 1928. Researchers worked primarily on solving problems related to cigar leaf and pipe tobacco production. Staff were also involved in research related to animal production and to crops suitable for production in the surrounding area. In later years, research work was focused mainly on tobacco replacement crops, such as corn and ornamentals. The Farm was closed in 1997 following the 1994 Program Review.

The early years, 1928–1985

L'Assomption Experimental Station was established in 1928 following the increase in cigar leaf and pipe tobacco production in the region. The Station's primary purpose was to meet the needs of producers in terms of fertilization and to perform cultivar tests on Burley and cigar leaf tobaccos. A cigar tobacco breeding program was launched in 1948 to develop high-yield, easy-to-dry and disease-resistant cultivars. In 1954, the tobacco research plots were relocated to the nearby Lavaltrie site, which had been purchased because of its sandy soil. A new pipe tobacco cultivar, L'Assomption 201, was registered in 1977. The breeding program was terminated in 1982 due to a sharp decrease in cigar tobacco production acreage and profitability. Research demonstrated that crop rotations were mandatory for tobacco production in very light sandy soils.

From 1929 to 1957, the Station had a Holstein dairy herd, and from 1955 to 1970 poultry breeding research was conducted. As well, crops such as rye, corn, soybeans and beans were studied in order to provide information to growers on irrigation, fertilization, weed management, and insect- and disease control.

In 1978, L'Assomption Experimental Farm became part of the Saint-Jean-sur-Richelieu Research Station. In 1981, research work began to investigate ornamentals as a crop that would thrive in the sandy soils left unused by former tobacco growers while filling a need for ornamentation in Canada's fast-growing cities. The winter hardy rose breeding program was transferred to L'Assomption from Ottawa. In 1984, replacement began of the old buildings that had been designed for tobacco, dairy and poultry research with new ones better suited to research focused on horticultural crops.

The beginning of the second century of research, 1986–1997

In 1986, the 80-hectare L'Assomption Farm and its 25-hectare field site in Lavaltrie were staffed by five researchers assisted by 15 other employees and led by a superintendent. Work on cigar leaf tobacco focused on the effects of various nitrogen and phosphorous sources in order to characterize their contribution to the agronomical and chemical characteristics of cigar leaf tobacco.

The researchers also carried out work in physiology, weed science, crop science, grain corn improvement, cultivar selection, flue-cured tobacco management, rose breeding and ornamental plant management.

In 1988, the mandate of the Farm shifted towards tobacco replacement crops, including ornamental plants. The shift was driven by a need to find the means to rehabilitate sandy soils that had been left partially vacant as a result of the reduction in flue-cured tobacco cultivation. The Farm was tasked with developing flowering hardy rose bushes that would be well suited to the eastern provinces of Canada, and with identifying adaptation zones for woody ornamental species. Plants suitable for the Prairies were to be developed at the Morden Research Station in Manitoba, and the two research teams worked in close collaboration. Research on hybrid tea rosebuds and hardy rosebuds led to the development of 50 new selections. Researchers developed a method for *in vitro* multiplication of 12 decorative *Prunus* cultivars, which allowed the plant nursery industry to quickly propagate clones and new *Prunus* cultivars in order to replace grafting in some cases (plum) and to reduce the impact of diseases common to *Prunus*.

Ornamental Woody Plant Testing Network

The Ornamental Woody Plant Testing Network of Quebec was founded in 1984 to promote ornamental hardy shrub plants in Eastern Canada in collaboration with a dozen partners from the federal and provincial governments and universities, as well as nursery gardeners from the private sector. Testing was conducted on nine sites in Quebec and in Kapuskasing, Ontario. The results of the 14 years of tests were published in a five-book series, *Rusticité et croissance des plantes ligneuses ornementales au Québec*. Aimed at nursery gardeners, it provides information on the behaviour of numerous species in every region of the province.

Among the other crops that were tested in sandy soils as possible substitutes for tobacco were strawberries, raspberries, highbush blueberries, Chinese cabbages, squashes, asparagus and melons. The scale of small fruit cultivation has subsequently greatly increased in this region.

Weed research was conducted, focusing on a demographic study of quackgrass rhizomes (*Elytrigia repens*, formerly known as *Agropyron repens*), which led to the discovery that these rhizomes survive no longer than two years in the soil whether it has been ploughed or not.

In 1993, the management of L'Assomption was integrated with that of the Saint-Jean-sur-Richelieu Research Centre and the name was changed to

L'Assomption Research Farm. The Program Review of 1994 led to the closure of the Farm and its field site at Lavaltrie in 1997. All programs were phased out except for the rose breeding program, which was transferred to Saint-Jean-sur-Richelieu.

New Facilities

A new, state-of-the-art research facility was built in 1992-1993. With a total area of 3,500 square metres, the building included an administrative area, a meeting room, a library, six offices for researchers, four research laboratories, six research greenhouses, growth chambers, cold rooms, a mechanical room and a machine shed. New research equipment was also installed. Most of the old buildings, designed for tobacco and poultry research, were demolished. The dairy barn, still in good condition, was kept (along with one other building) and used as a machine shed.

The City of L'Assomption acquired the Farm's main buildings and created the *Carrefour industriel et expérimental de Lanaudière*, dedicated to applied research in agriculture and horticulture. In 2001, the City of Montreal bought the Farm's land and transferred its tree nursery there. The Lavaltrie site was sold to the town of Lavaltrie, which worked with the local college in Joliette (CEGEP) to establish a program to teach irrigation on the site.

Research highlights between 1986 and 1997

- Confirmed that iron was the only cause of streak and rust spot associated with the appearance of grey tobacco
- Created two rose bush cultivars (Champlain and John Franklin), two tea hybrids (Landora and Jean-Paul II) and four new hardy rosebud cultivars (Captain Samuel Holland, Louis-Jolliet, Frontenac and Simon Fraser)

- Helped develop the Explorer rose series—named after Canadian explorers—which are hardy roses with exceptional flowering characteristics; Canadian nurseries increased their production as a result of increased consumer demand for these plants
- Developed a new technique for irradiating plants with Cobalt 60 to produce rosebud mutations. Twenty-nine potential varieties of miniature rosebuds of all colours were selected from the more than 500 lines of rosebuds produced in 1991. These varieties have been available to the industry since 1997
- By conducting tests on sandy soils, showed that strawberries, raspberries, highbush blueberries, Chinese cabbages, squashes, asparagus and melons offered alternatives to tobacco producers
- Revealed that nitrogen in the form of urea, and phosphorous as a single superphosphate, was the best fertilizing combination to use for tobacco crops
- Carried out original research to reduce the use of herbicides in the cultivation of sweet corn and other vegetables (e.g. carrots, lettuce); the use of intercropping and hoes was promoted to industry
- Published the results of the Ornamental Woody Plant Testing Network of Quebec in a series of five books in 1995, 1997, 1999, 2001 and 2003

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Greenhouse and Processing Crops Research Centre
Harrow, Ontario

Catherine A. Fox, Vaino Poysa and Craig F. Drury, Research Scientists,
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A research facility was established at Harrow in 1909 to provide agricultural research support for agricultural management practices and for the major field crops (tobacco, oats and winter wheat), peaches, and cattle. By the 1980s, research focused on commodity-oriented programs that addressed regional issues related to field crops and horticultural crops including field vegetables, greenhouse vegetables, and tree fruits. Harrow became the home of the Canadian Clonal Genebank in 1996. Over the past 25 years the Greenhouse and Processing Crops Research Centre has made significant contributions to improving the productivity and profitability of field crops, horticultural crops and greenhouse vegetables, and improving soil water and air quality, as well as protecting and conserving the genetic diversity of Canadian bioresources.

The early years, 1909–1985

A research facility was established at Harrow in 1909 as a tobacco research station. By 1923, it was known as the Experimental Station and in 1959, it was renamed the Harrow Research Station.

From its beginnings, the Station provided agricultural research support for the major field crops (tobacco, oats, winter wheat), peaches, and cattle, and for agricultural management practices related to soils. From 1923 to 1930, Harrow undertook soybean evaluation in conjunction with the Central Experimental Farm in Ottawa, as well as the breeding and testing of corn hybrids as a response to the discovery of European corn borer in Ontario.

In 1930, poultry and soybean breeding programs were initiated, along with entomological research on field crops, tree fruits and vegetables.

In 1947, soil and water quality research was initiated, focusing on soil fertility requirements for potatoes, corn, oats and alfalfa, irrigation for potatoes, and all phases of the water relations of soils and crops, in an effort to achieve optimum yields and improve environmental quality.

The 1950s saw the release of new soybean and corn varieties, including the soybean cultivar Harosoy, the most important ancestor of most of the soybeans currently grown in Canada and the northern U.S. The dry bean breeding program began in 1956 with emphasis on disease resistance.

In the early 1960s, a tree fruit (peach, nectarine and pear) breeding program and a weed research program (control of weeds in horticultural and field crops) were initiated, while the poultry program was concluded.

In the 1970s and 1980s, Harrow researchers developed and released the Harcor soybean, Harliton seedless greenhouse cucumber, and the Harus wheat plant, which became the dominant variety in soft white winter pastry wheat.

In 1984, Harrow's tomato breeding program was re-established at the request of growers and processors, with emphasis on germplasm development (including disease and insect resistance, stress tolerance, yield, and fruit quality).

The beginning of second century of research, 1986–2011

From 1986 to 1994, the research teams at the Harrow Research Station comprised between 27 and 32 researchers. The focus of the research was commodity-oriented programs that addressed regional issues related to field crops (corn, soybeans, field beans and winter wheat), horticultural crops of field vegetables (cruciferous crops, green peas, tomatoes and peppers) and greenhouse vegetables (cucumbers, tomatoes and peppers), as well as tree fruits (apple, apricot, peach and pear).

In addition, a soil, water, and air quality team was formed to develop management practices to improve soil quality, reduce greenhouse gas emissions, reduce nutrient-leaching losses to the environment, and improve crop productivity. A weed research team continued to address the control of weeds in horticultural and field crops, and to assess yield losses.

Soil and Water Environmental Enhancement Program

From 1986 to 1989, Harrow Research Station contributed to the Soil and Water Environmental Enhancement Program (SWEEP), specifically in the Technology Evaluation and Development (TED) sub-program (managed by Ecological Services for Planning Ltd., Guelph). This initiative provided for field experiments to develop new conservation methods, tillage and cropping systems, and fertility and water management methods under commercial-farm conditions. SWEEP was administered by the Department and was carried out by the province of Ontario.

In the late 1980s, a research project, in co-operation with the University of Guelph, focused on biological control testing in apple orchards for the management of codling moth. The *granulosis* virus was found to be an attractive alternative to broad-spectrum chemical insecticides. Harrow's peach breeding research was directed towards developing cultivars for cold tolerance with respect to bud and wood hardiness, yield, the impact of irrigation, and resistance to drought. Its pear breeding research examined cultivars for resistance to fire blight in combination with fresh fruit quality (appearance and size, flavour and texture).

In 1990, the soils and water quality team, with support from the Great Lakes Water Quality program, designed and constructed an automated facility with enhanced remote capability at Woodslee for continuous real-time monitoring of surface runoff and tile drainage. Detailed water quantity-and-quality data have been collected since 1992 for developing soil, crop and water management systems.

Breeding programs for commodity field crops were a strong component of research at Harrow, especially from 1986-1995. With tomato breeding re-established, variety research for processing tomatoes focused on improving disease and insect resistance, stress tolerance, yield, and fruit quality. Field-bean breeding and genetics research was directed toward identifying varieties resistant to diseases such as anthracnose, common bacterial blight, and mosaic virus. Corn breeding research focused on shortening the growing period. Soybean research concentrated on improving quality for the food-grade market, and on developing the plant's resistance to *Phytophthora* root rot, while wheat breeding research focused on resistance to Fusarium scab, a disease that severely reduces the economic value of wheat crops.

For greenhouse horticulture crops, research during 1988-1990 focused on the biological control of cucumber powdery mildew using yeast-like *Sporothrix* spp., and in tomatoes, Fusarium crown and root rot, using antagonistic filamentous bacteria (*Streptomyces* spp.). From 1988 to 1994, a new complex of nine mini-greenhouses was used to evaluate glass, double-inflated polyethylene and rigid twin-wall acrylic panels as greenhouse covers, by measuring tomato and cucumber yield in relation to energy use.

By 1995, the Centre—renamed the Greenhouse and Processing Crops Research Centre—employed 22 researchers working on biological sciences, plant science and integrated crop production systems. In subsequent years, changes in programs and reporting responsibilities included the following:

- A large part of the wheat breeding program was moved to the Eastern Cereal and Oilseed Research Centre in Ottawa, with only field trials run at Harrow;
- The corn inbred development breeding program was discontinued;

- The peach, apricot, nectarine and pear breeding programs were terminated at Harrow; a part of the pear breeding research program was transferred to Vineland;
- The Canadian Clonal Genebank (for apples, strawberries, currants and raspberries) was relocated to Harrow from the Smithfield Experimental Farm;
- The Department's Land Resource Unit in Guelph began to report directly to Harrow until the unit closed in 1998;
- Research on soils was strengthened with programs in soil physics, biochemistry and ecology; and
- The soybean breeding program continued at Harrow and in the early 1990's the molecular biology and genomics program was established to address the need for molecular marker-assisted selection of soybean and white bean.

In 1996, the Canadian Clonal Genebank was relocated from Smithfield Experimental Farm to Harrow. The accessions are either preserved live in the field (tree fruits, raspberries, currants and gooseberries), under protected culture in specialized greenhouse facilities (strawberries and blueberries), or using *in vitro* cultures, in addition to seeds under refrigerated storage. Accessions numbered 3,255 in total in August 2010 and included the following: 1,692 *Fragaria* (strawberry), 823 *Malus* (apple), 256 *Prunus* (stonefruit), 122 *Pyrus* (pear), 100 *Ribes* (currant and gooseberry), 167 *Rubus* (raspberry), 26 *Rosa* (rose), 12 *Sambucus* (elderberry), 7 *Vaccinium* (blueberry), 12 *Hydrastis* (goldenseal), 2 *Cydonia* (quince) and 36 miscellaneous accessions that have not been classified. Various methodologies have been developed to preserve and propagate the accessions.

In 1999, new state-of-the-art 4.3-metre-high greenhouses for vegetable research were commissioned, with 16 compartments of double polyethylene and four of glass, totalling 3,200 square metres. The new greenhouses also featured fertigation controls, shade curtains, a high-efficiency boiler, cooling and fogging capabilities for enabling advanced studies in greenhouse vegetable physiology and management, pest and disease control, energy use and environmental control.

Since 2002, the Centre has been one of nine Canadian locations collaborating on the Minor Use Pesticide program. This is a joint initiative between the Department and the Pest Management Regulatory Agency to conduct field trials and laboratory analysis for weed and pest control management in order to enable registration of new minor uses of pesticides for low-acreage, high-value crops such as horticultural crops.

In 2003, the tomato breeding program was ended, and the germplasm and breeding lines were transferred to the Ridgetown College of Agricultural Technology. Greenhouse research focused on assessing an ultra-low-nitrogen-oxide, direct-contact, high-efficiency combustion boiler for heating and greenhouse carbon dioxide (CO_2) enrichment. Harrow scientists made significant progress in understanding the influence of greenhouse climate on integrated pest management programs, and in the development of novel approaches of using bee pollinators to deliver microbial agents for pest and disease control. Harrow was the leader in the development of integrated pest management programs for thrips on greenhouse ornamental crops, using trap plants, nematodes and predatory mites.

The weed management and ecology program focused research on environmentally and economically sustainable weed management systems for field and vegetable crops, addressing organic agriculture systems, invasive weeds and the impact of climate on weed biology.

Plant pathology research, conducted in collaboration with greenhouse specialists at the Ontario Ministry of Agriculture, Food and Rural Affairs, identifies the etiology and epidemiology of new emerging diseases affecting the greenhouse industry, develops appropriate disease control measures, and ensures the sustainability of the greenhouse industry.

Soybean breeding, white bean breeding, molecular biology research and food quality programs are ongoing at Harrow. New technologies are being studied to evaluate quality aspects of food-grade soy for the Pacific Rim and North American markets in support of both the breeding program and industry. For soybeans, the emphasis is on developing high-yielding cultivars with protein composition profiles that exhibit the functional, nutritional and processing qualities required by traditional and new soy food markets, as well as disease and insect resistance. For white beans, the emphasis is on yield and disease resistance.

The Woodslee Research Farm

A 67-hectare Experimental Station was established at Woodslee in 1946 to undertake specialized research for field crops grown on Brookston clay loam soils, a major fine-textured soil in southwestern Ontario. (It was named the Honourable Eugene F. Whelan Experimental Farm in 1984 and the Honourable Eugene F. Whelan Research Farm in 1996.) Soil and water quality studies began in the late 1950s, including the establishment in 1956 of a crop rotation fertility study that is still being used today. A further 16.7 hectares were purchased in 1977 in support of weed research. In 1983, tillage studies were initiated to examine the impact of conservation tillage (no till and ridge tillage) and conventional tillage (fall ploughing and spring disking) on soil and water quality.

In 1996, the Woodslee Research Farm's long-term field site, which had been established in 1956, was documented as a Food and Agriculture Organization-UNESCO Global Terrestrial Observing System site. In 1992, a water collection building was constructed at Woodslee in support of nutrient run-off monitoring. In 1998, 18.5 hectares were acquired to enhance the soil and water quality research program.

In 2007, upgrades included four water reservoirs (ponds) for water recycling and improved monitoring for the Woodslee long-term (since 1956) fertilization and crop rotation plots, with a new building to monitor surface and sub-surface water flow from fertilized and unfertilized cropping treatments.

The soil research efforts at Woodslee have produced a legacy for Agriculture and Agri-Food Canada of six long-term (10 to 52 years) field studies that emphasized soil and water management, fertilization, and crop rotations. Assessment of these cropping systems with respect to energy use has been ongoing since the mid-1990s through collaboration with an agricultural engineer from the Eastern Cereal and Oilseed Research Centre. In addition, soil research during the past decade has emphasized air, water and soil quality—primarily through field studies examining tillage type, amendment source, timing and application methods, impacts on water quantity, nutrient dynamics, and transformation pathways (i.e., nitrogen and phosphorus leaching). To undertake this research, the soils team has received funding from the following sources: Green Plan; Program of Energy Research and Development; National Agri-Environmental Health Analysis and Reporting Program; Environmental Technology Assessment for Agriculture; Model Farm Program; Sustainable Agriculture Environmental Systems; Green Cover Canada; and the Agri-Food R&D Matching Investment Initiative.

Research highlights over the past 25 years

- Formed a soil, water and air quality team to develop management practices to improve soil quality, reduce greenhouse gas emissions, reduce nutrient leaching losses to the environment and improve crop productivity
- Introduced in 1989 a new apricot, Harval, and a nectarine, Harblaze, for the Ontario fresh fruit market, both being cold-hardy, consistently productive, highly resistant to bacterial spot, brown rot and canker, resistant to skin cracking and pre-harvest drop, and suitable for long-distance shipping because of firmness and colour at shipping maturity
- Built specialized facilities and collected detailed water quantity-and-quality data for developing soil, crop and water management systems in order to increase crop water-use efficiency and abate nitrogen, phosphorus, and pesticides as a result of agricultural practices related to corn production, crop rotation and the application of amendments
- Developed a sub-irrigation water recycling system that captures excess water during wet periods and returns it to crops during dry periods, resulting in increased crop yield and reduced water pollution
- Developed the Harovinton soybean (licensed in 1989), which reigned as the tofu-quality standard for Canadian soybeans for more than two decades, was recognized as Seed of the Year, and was responsible for greater Japanese market acceptance of Canadian soybeans

- Registered and released AC Compass, a new field bean variety with high yield and resistance to bean common mosaic virus
- Developed and patented the Harrow Fertigation Manager software application to manage the provision of timely nutrients to both greenhouses and fields from standard sets of fertilizer stock solutions; the software allows the greenhouse industry to reduce labour costs and improve crop yield and quality
- Played a lead role in obtaining the first registration of an entomopathogenic fungus (*Beauveria bassiana*) for control of agricultural pests in Canada, and was the lead player in the development of integrated pest management programs for thrips on greenhouse ornamental crops using trap plants, nematodes and predatory mites
- Developed the first quantitative survey of plant virus occurrence in greenhouse vegetables in southern Ontario
- Identified fungal and bacterial diseases new to Canadian greenhouse vegetable production and developed control measures for them
- Made commercially available the soft white winter pastry wheat variety Ena, which is high-yielding and tolerant of Fusarium and leaf rust
- Designed Harrow Greenhouse Manager and Enerpass for Greenhouses software to help growers make management decisions for vegetable production and energy use
- Demonstrated significant energy-use reduction when using double polyethylene or double acrylic panels as greenhouse covers as compared to glass panels
- Released weed-control software—the Herbicide Application Decision Support System—that incorporates evaluation of the net benefit of options for pre- and post-emergence control, and includes information on managing herbicide resistance

- Field vegetable research led to innovations in the areas of irrigation management, pest control and the use of mulches for growers
- Maintains and manages the Canadian Clonal Genebank (for apples, strawberries, currants and raspberries), which is a very valuable source of genetic material for breeders

Eighteen researchers were working at Harrow as of 2011, with one white bean breeder located at the University of Guelph. Key research activities are currently organized with reference to three science priorities: enhancing economic benefits for all stakeholders; enhancing environmental performance of the Canadian agricultural system; and enhancing understanding of Canadian bioresources and protecting and conserving their genetic diversity.

The Greenhouse and Processing Crops Research Centre focuses on new technologies for producing greenhouse crops, including vegetables and ornamentals, and field-grown processing crops, including soybeans, edible beans, corn, winter wheat and tomatoes. Research on the quality and sustainable use of Ontario soils, and the reduction of greenhouse gas emissions and nutrient losses from agricultural soils are also significant activities at the Centre, calculated to enhance the environmental health of farmlands.

Smithfield Research Farm
Smithfield, Ontario

Catherine A. Fox, Research Scientist, Research Branch, Harrow
Margie Luffman, Curator, (1990-1996), Research Branch, Smithfield
John Warner, Program Leader (1993-1996), Research Branch, Smithfield

The Smithfield Horticulture Station was established in 1944 near Trenton, Ontario as a unit of the Central Experimental Farm. Its mandate was to undertake research on the fruit and vegetable crops that were being grown in the region. In 1960, the Smithfield Station became an independently managed experimental farm. Research programs focused on processing crops, tree fruit nutrition and physiology, vegetable breeding and evaluation, tomato breeding, vegetable management, herbicide and irrigation studies. In 1988, Smithfield became the primary departmental site of the clonal repository of the Plant Gene Resources of Canada program. In 1996, following Program Review, the Smithfield Research Farm was closed and the Clonal Genebank was moved to the Harrow Research Centre.

The early years, 1944–1985

The north shore of Lake Ontario had long been a profitable apple-producing area, but by the mid-1930s, major problems due to winter tree kill and disease had severely reduced production. In 1944, the Department of Agriculture obtained funds to purchase land in order to establish the

Smithfield substation on 40 hectares of land near Trenton. The substation was managed as a unit of the Central Experimental Farm and had a mandate to perform experimental fieldwork and research on fruits and vegetables.

Research focused on orchard management, rotation of processing crops such as peas, corn and tomatoes, variety trials on vegetables and small fruits (especially strawberries, raspberries and currants), soil management studies for growing pickling cucumbers, spacing trials with peas and corn, as well as fertilizer studies for tomatoes.

In 1953, in order to expand research for the development of scab-resistant apple varieties, 80 hectares were purchased adjoining the west boundary of the substation to accommodate thousands of apple seedlings. In 1956, field studies expanded, with intensive field trials of vegetable and small fruit management, including irrigation and chemical weed control studies. In 1959, Smithfield built a pilot processing plant with a fully equipped kitchen for sensory evaluation to enable research on the relationship between raw product grades and the quality of the processed crop after freezing or canning.

In August 1960, Smithfield became an independently operated experimental farm, emphasizing research on vegetable management, herbicides, irrigation and chemical weed control in canning crops. During the following decade, research was increased in the areas of food-processing evaluation, vegetable breeding and evaluation, tree fruit nutrition, physiology and biochemistry, as well as fruit crop management.

Throughout the 1970s, parts of programs were transferred from Ottawa, including the tree fruit breeding program, the program for evaluating scab-resistant apple selections in second test orchards, and the tomato breeding program, which screened for verticillium wilt, bacterial canker and tomato speck resistance. As part of the Smithfield tomato program, cooperative variety and advanced seedling trials were undertaken with provincial agriculture stations at Ridgetown and Simcoe, the University of Guelph and the federal station at Harrow. In 1975, Smithfield began to report to the Vineland Research Station (Niagara Region), Smithfield's program having become oriented toward the protection of fruits and vegetables from an entomology perspective, which was similar to what Vineland researchers were doing.

By the early 1980s, research at Smithfield was focused on plant physiology, orchard density and meristem culture, food processing and technology, vegetable management and herbicides, orchard management, pest management, tree fruit variety and rootstock evaluation, tomato breeding, vegetable evaluation, and Ontario grain-corn committee trials.

The beginning of the second century of research, 1986–1996

As Smithfield continued its research mandate, its five researchers worked closely with the local apple growers association and with processing, seed and chemical companies. For example, chemical companies provided funding to test new products for pest control in apples. Smithfield researchers also worked closely with colleagues at the Vineland Research Station to evaluate new pest control methods, both chemical and non-chemical, and with departmental colleagues in Summerland and Saint Jean-sur-Richelieu to evaluate new apple varieties, including scab-resistant varieties. Research was also undertaken with the Ontario Ministry of Agriculture, Food and Rural Affairs to evaluate plums, pears and apple rootstocks. The apple rootstock evaluation was an international effort headed by the International Dwarf Fruit Tree Association that resulted in the publishing of research results as well as the release of apple varieties. In the 1990s, research in vegetable management, food processing and tomato breeding ended.

In 1988, Smithfield was chosen as the primary site for the clonal repository of the Plant Gene Resources of Canada program because it had available land resources, a suitable climate, and research and field experience in orchard and fruit management. The genebank served as the national repository for Canadian tree fruit and small fruit germplasm. Its mandate was to protect and preserve the genetic diversity of Canadian fruit crop plants and their wild relatives. This was accomplished by collecting, maintaining, documenting, researching and evaluating genetic resources in order to ensure the long-term maintenance and availability of material for national and international plant studies and breeding programs.

In 1992, when Vineland Research Centre began reporting to London Research Centre, Smithfield began to report to the London Research Centre through Vineland. In 1993, it was renamed the Smithfield Research Farm.

By 1996, before its closure, the clonal genebank comprised 2,908 accessions of *Fragaria* (strawberry), *Malus* (apple), *Prunus* (stonefruit), *Pyrus* (pear), *Ribes* (currant and gooseberry), *Rubus* (raspberry), *Rosa* (rose), *Sambucus* (elderberry), and *Vaccinium* (blueberry). The program undertook the preservation of plant materials—as live material in fields, or under protected culture in greenhouse or shade facilities, or as *in vitro* cultures, or as seed samples in refrigerated storage. Sixty-five percent of the collection comprised indigenous-species germplasm, with the remainder being named cultivars, mostly of Canadian origin.

The Smithfield Research Farm was closed on November 1, 1996. The clonal genebank program was moved to the Greenhouse and Processing Crops Research Centre at Harrow. Forty hectares of the Smithfield land base were sold and the remaining 80 hectares was rented to local growers.

Research highlights between 1986 and 1996

- Identified as the primary site for the clonal repository of the Plant Gene Resources of Canada program because of available land resources, suitable climate, and research and field experience in orchards and fruit management
- Protected and preserved the genetic diversity of Canadian fruit-crop plants and their wild relatives by collecting, maintaining, documenting, researching and evaluating genetic resources in order to ensure the long-term maintenance and availability of material for national and international plant studies and breeding programs
- With the Ontario Ministry of Agriculture, Food and Rural Affairs, evaluated cultivars of plum and pear trees as well as apple rootstocks, the latter being an international effort headed by the International Dwarf Fruit Tree Association that resulted in the publishing of research results and the release of apple varieties

Southern Crop Protection and Food Research Centre London, Ontario

A. Bruce Broadbent, Research Scientist, Research Branch, London

Founded in 1951 on the Campus of the University of Western Ontario at London, the Southern Crop Protection and Food Research Centre has evolved considerably over the years, shifting its main emphasis away from research into pesticide biochemistry and toxicology and toward crop protection, crop improvement and molecular farming. In 1988, the first staff members moved from the university campus to a new facility in the northeastern part of the city. Final consolidation of staff at the new site was completed in 2000. The Centre has become known for research in insect and disease management, genomics and biotechnology, and environmental risk mitigation. It has built strong links with national programs and collaborators across Canada and internationally.

The early years, 1951–1985

In 1951, the federal Science Service Laboratory was officially opened on the campus of the University of Western Ontario in London. The mission of the laboratory was to investigate the development and effects of synthetic organic pesticides in agriculture. The research was devoted to entomology, plant physiology, plant pathology and chemistry.

The "London Laboratory" played an important role at the University of Western Ontario as federal researchers undertook collaborative research programs in the important field of crop protection. Departmental researchers served as adjunct professors, presented lectures and acted as co-supervisors of graduate students in the plant sciences, zoology, chemistry and microbiology departments.

In 1960, following the formation of Research Branch, the laboratory became known as the Pesticide Research Institute.

In 1967, the Soil Pesticide Section was formed to study insect pest management and to evaluate the efficacy and residual activity of pesticides both in treated crops and in the environment. It was staffed by researchers from the closed Chatham Entomology Laboratory, and was housed separately in downtown London. In 1979, the Institute was renamed the London Research Centre.

The beginning of the second century of research, 1986–2011

In 1986, the London Research Centre had 26 researchers and was conducting studies in three programs: mode of action of selected and potential insect control agents; mode of action of selected and potential plant-pathogen control agents; and soil pesticides.

Over a period of 15 years, the London Research Centre underwent a series of scientific and infrastructure changes. These began in 1988 with the transfer of Soil Pesticide Section staff from downtown London to newly constructed facilities on Sandford Street—the current location of the Centre—in northeast London.

In 1991-1992, researchers were organized as two teams: entomology and pathology. This changed in 1993 to alternative pest control and vegetable and field crops, and in 1994 to soil and water resources and germplasm and alternative pest control. The Centre was expanding its mandate from crop protection to more basic questions of crop genetics and food safety.

Siebens-Drake Research Institute (SDRI)

In 1991, an alliance between the Department, the University of Western Ontario, the John P. Robarts Research Institute and the London Health Science Centre led to the creation of the Siebens-Drake Research Institute (SDRI). It was named after Harold Siebens, philanthropist, and Charles Drake, neurosurgeon at the University of Western Ontario. Funding was provided by Harold Siebens, the Government of Canada and the Government of Ontario. The Department's building on the university campus was refurbished and surrendered to the university to become the home of the new Institute. The SDRI conducts leading-edge molecular and cellular biology studies of humans, plants and insects. A secondary objective is to facilitate cooperative research in the agricultural and medical fields.

In 1993, the London Research Centre became the Pest Management Research Centre, having assumed administration of the Vineland Research Station, the Delhi Research Farm and the Smithfield Research Farm the year before. This change was made in an effort to reduce the administrative costs within Research Branch.

The Centre's researchers were organized into three programs (soil and water resources, vegetables, and field crops) in 1995-1996, and subsequently into two programs (crop science, soil and environmental science) in 1997, primarily as a response to increasing recognition of the importance of protecting the environment.

The Centre was renamed the Southern Crop Protection and Food Research Centre in 1998 and became responsible for Research Branch's new Food Research Program at the University of Guelph until 2000.

In 1999, scientific expertise in both basic and applied science was integrated into a unified program at the new facility, with research funding being provided through the Department's Crop Genomics Initiative. With the termination of tobacco crop research at Delhi in 2000, four researchers from Delhi were transferred to London.

By 2006, research projects began to be subjected to peer review, and programs that historically had been managed locally were being assigned to national teams of researchers. This provided an opportunity to develop stronger links with colleagues across Canada.

As of 2011, London had 22 researchers in three major programs: crop genomics and bioproducts; environmentally sustainable production systems; and the protection and improvement of fruit and vegetable crops. It was also taking part in the Minor Use Pesticides Program, initiated in 2002, with fieldwork being undertaken at Delhi and Vineland. Overall, the Centre had 82 employees in 2011.

Major facilities at the London location include a 25-hectare research farm, a new state-of-the-art greenhouse and bio-containment facility, controlled-environment growth rooms, insect production facilities and sophisticated scientific equipment, including confocal microscope and a next generation DNA sequencer. The Centre has a continuum of upstream and downstream expertise in the diverse fields of plant biology, entomology, microbiology, molecular biology, genomics, agronomy, plant pathology, chemistry and soil science. Researchers collaborate extensively with other colleagues, producer groups, and the agri-industry, as well as with a wide range of national and international partners that includes researchers in the U.S., Brazil, Germany, Switzerland, France, Israel, China, South Korea, Australia, and the U.K. The Centre also maintains special relationships with the University of Western Ontario and the University of Guelph.

London's research program has evolved in the past two decades, shifting its main emphasis away from pesticide biochemistry and toxicology and toward crop improvement and crop protection (using modern molecular tools including -omics technologies), and biological control and environmental risk mitigation. It has become one of Canada's leading institutions in these disciplines.

Research highlights over the past 25 years

- Monitored Colorado potato beetle insecticide-resistance development, which contributed to registration of effective replacement insecticides and the development of resistance management programs

- Developed SPORODEX—the first bio-fungicide to be collaboratively discovered, developed and registered in Canada—to biologically control powdery mildew diseases in greenhouse-grown cucumbers and roses
- Significantly advanced knowledge of the means by which plum pox virus replicates and moves in host cells; identified a host gene that can be used to control it; and generated transgenic plum that is highly resistant to it
- Identified *Pseudomonas syringae* pv. *tomato* DC3000, a causal agent for bacterial speck on tomato and on the model plant *Arabidopsis*, which became an important model in molecular plant pathology and is now used by many labs worldwide
- Identified, in collaboration with Japanese colleagues, a key gene (*Lhkl*) responsible for enabling legumes to host nitrogen-fixing bacteria
- Released and established in Ontario a European species of minute parasitic wasp, *Peristenus digoneutis*, as a biological control agent of the insect pest *Lygus lineolaris*
- Demonstrated that dry bean seed lacks the usual major storage proteins, phaseolin and lectins, but has improved levels of sulphur amino acid, methionine and cysteine, which are essential for nutrition
- Identified the *Phytophthora sojae* avirulence (*Avr*) genes *Avr1a*, *Avr3a*, and *Avr3c* to aid root rot diagnostics and management, and cultivar development for soybeans
- Showed that organic soil amendments can control a wide spectrum of soil-borne plant pathogens, including bacteria, fungi, nematodes and weeds, while increasing populations of soil microorganisms
- Developed a novel method (now practiced internationally) of using recombinant-protein-producing tobacco leaves to create designer therapeutic proteins useful in the treatment of auto-immune diseases such as diabetes and Crohn's disease, as well as the production of industrial proteins

- Elucidated the biochemical pathway of the stevia sweetener and improved the stevia breeding lines
- Showed that one of the key elements of responsible land application of agricultural fertilizers is to keep the applied material in the rooting zone away from groundwater and surface water sources by using: better management practices for land application; tillage to incorporate material into the soil; and application of material during periods when the potential for leaching is low
- Validated risk-mitigation measures related to the application of animal manure and municipal biosolids on agricultural land; established beneficial management practices that protect both surface waters and agricultural land; and contributed to environmental risk assessments of human and veterinary pharmaceuticals

The Southern Crop Protection and Food Research Centre's research mandate is: to develop alternative and environmentally acceptable technologies to protect crops from insects and disease (including the use of biological control organisms and bio-pesticides); to determine the impacts of agricultural practices on soil and water quality; to develop efficacy and residue data to support registration of pesticides for use on minor crops in Canada; and to use molecular tools to understand growth and crop production processes at the molecular level.

The Centre is a research facility in London with diverse scientific expertise that emphasizes insect/disease management, genomics/biotechnology and environmental risk mitigation. It strives to maintain the relevant continuum of upstream and downstream research that is essential to progress.

Acknowledgements

Thank you to Drs. Bruce Bowman, Frank Marks, Jeff Tolman, Karl Volkmar and Gary Whitfield for their valuable critical review.

Delhi Research Farm
Delhi, Ontario

Peter White, Biologist, Research Branch, Delhi
Jeff Tolman, Research Scientist, Research Branch, London

Since its foundation in 1933, the Delhi Research Farm has adapted to meet changing societal demands and economic priorities in agriculture. Formerly known as a substation of the Harrow Experimental Station, it was renamed the Delhi Experimental Farm in 1962, and the Delhi Research Station in 1967. For several years, Delhi was recognized as a tobacco crop research facility. In the early 1980s, new research programs were initiated to identify and adapt alternative crops for tobacco producers and to optimize water use and improve the structure and fertility of the area's unique sandy soil resource. In 1992, Delhi reported to the London Research Centre and was renamed the Delhi Research Farm a year later. By the year 2000, the federal government was no longer conducting research on tobacco crops.

The early years, 1933–1985

The Delhi research facility was founded on the Norfolk Sand Plain in 1933 to conduct research on flue-cured tobacco; an increased demand had shifted production from Essex and Kent counties in the 1920s to the coarse sandy soils of Norfolk and neighbouring counties. The Department established a substation of the Harrow Experimental Station on 20 hectares of leased land just west of Delhi to carry out research on tobacco production. In 1938, the government purchased the leased property and an adjoining additional 20 hectares.

In the early years, because of the susceptibility of the sandy soil to wind erosion and drought, much of the research program was directed towards maintaining and increasing soil stability and fertility, and the quantity of organic matter, through studies of windbreaks, crop rotations, tillage, fertilization, and cultural practices. Variety trials were conducted and new varieties were developed.

Research expanded in the late 1940s to include agronomy and plant breeding in addition to soil science. In the early 1950s, research emphasized disease and nematode control.

In 1962, the Delhi establishment was designated as an experimental farm, no longer subordinate to the Harrow Research Station. With the purchase of an adjoining farm in 1965, the land area was increase by 20 hectares. In 1967, it became the Delhi Research Station.

In the 1960s and 1970s, there was an increase in research on plant breeding, plant genetics, entomology, plant pathology, plant physiology, weed science and chemistry of tobacco. In addition, tobacco extension specialists from the Ontario Ministry of Agriculture were relocated to Delhi. The combination of research and the transfer of information on new varieties improved cultural practices as well as disease, nematode and insect control, resulting in improvements in the yield and quality of tobacco crops.

The beginning of the second century of research, 1986–2011

In 1986, a staff of 40, including eight researchers, carried out research both on the 60-hectare farm and at several off-site locations. Active programs included entomology, soil management and fertility, chemistry, plant pathology, genetics and plant breeding, weed science and plant physiology. Research focused on flue-cured tobacco production on the sand plains of southern Ontario.

Delhi researchers continued to develop new tobacco cultivars, supported by soil fertility trials, resulting in increased yields and quality. Surveys were conducted on a large number of farms to analyze the chemistry of the farm-grown tobacco crop. Entomology studies assessed the severity of insect infestation of the tobacco crop and led to effective management practices for insect pests. Fungicides were evaluated for control of a variety of diseases, especially potentially devastating blue mold. More effective tobacco seedling production techniques, weed control, and harvesting and processing methods were developed and implemented.

Collaboration

Three specialists from the Ontario Ministry of Agriculture, Food and Rural Affairs were located at the Station. In addition, the Delhi Engineering Research Group, funded by the Ontario Flue-Cured Tobacco Growers' Marketing Board and the Canadian Tobacco Manufacturers' Council contributed to a variety of applied research projects in support of tobacco production. These projects were related to the development of new and improved equipment for crop establishment, field management, harvest, curing and energy conservation.

In the 1980s, to diversify production options for growers, a new crops program was initiated, investigating potential crops that would do well in southern Ontario's coarse-textured soils. Over the years, 23 different crops were evaluated, including peanuts, winter canola, beans, chickpeas, evening primrose, paste tomatoes, and sweet potatoes. In response to increasing environmental awareness, research was initiated to optimize soil management practices that reduce nutrient leaching and enhance soil quality.

In 1992, the London Research Centre assumed responsibility for the management of the Delhi Research Station, which was renamed the Delhi Research Farm in 1993. New research focused on biological control of nematodes using rotation crops such as millet and marigolds, and on the evaluation of additional alternative crops such as kenaf, peppermint, ginseng and stevia.

By 2000, the focus of research at Delhi had moved away from tobacco and onto other crops. A new laboratory building was constructed to replace old buildings and to conduct research on high-value crops adapted for sandy soils. The Canadian Tobacco Research Foundation, created in 1994 by the tobacco industry and growers, subsequently assumed responsibility for tobacco research.

By 2001, four researchers had transferred from Delhi to London. The 20 staff members remaining on site continued with a program directed by researchers in London in conjunction with colleagues at the Vineland Research Farm. More detailed irrigation studies were initiated to address inherent low water-holding capacity and the potential for nutrient leaching on the Norfolk Sand Plain. These studies developed irrigation and fertigation schemes for high-value crops, using processing cucumber as a model.

Development of New Crops

In 1994, a research team involving the Department, the Ontario Ministry of Agriculture, Food and Rural Affairs, and the University of Guelph began investigating the pathology, chemistry, agronomy, fertility and the genetics of the ginseng crop in collaboration with the Ginseng Growers Association of Canada.

As well, collaboration with industry was initiated to develop improved varieties of stevia, a natural low-calorie sweetener, and to optimize production practices for the crop.

In 2002, Delhi was designated as a field site for the Department's new Minor Use Pesticides Program. Under the direction of the Pest Management Centre in Ottawa, minor use crops are grown and pest control strategies applied in order to develop residue and efficacy data for the licensing of conventional pesticides and bio-pesticides for minor use and risk reduction.

Three researchers were conducting research at the Delhi Research Farm in 2011. Soils research was determining the impact of management practices on soil organic matter dynamics. Investigations are under way: to determine the efficacy of selected soil organisms as biological control agents for soil-borne diseases or as bio-fertilizers for vegetable and field crops; to evaluate the non-target impact of potato that has been genetically modified to resist Colorado potato beetle; to optimize agronomic practice for plants genetically modified to produce pharmaceutical proteins; and to evaluate bio-pesticides for management of fire blight in apples and pears.

Research highlights over the past 25 years

- Evaluated the suitability of more than 20 crops as alternatives to tobacco for growth on the Norfolk Sand Plain; one product of this program is OAC Garroy, the dominant Valencia peanut grown in Ontario
- Showed that over-seeding a rye crop into a standing corn crop in August reduces nitrogen-leaching
- Demonstrated that tillage had little impact on crop production or the amount of carbon and nitrogen returned to the soil in the form of crop residues
- Developed a conservation delivery system for tillage manure nutrients in conjunction with Ontario Pork and several industry partners, including identification of the proper components of a manure delivery system to optimize corn yields, while reducing nitrate run-off, erosion and odour
- Developed an irrigation and fertigation scheme, using processing cucumber as a model crop, that increased yields and economic returns, and demonstrated that micro- or drip irrigation coupled with fertigation increased water and nutrient-use efficiency and reduced leaching losses
- Developed as many as 15 tobacco varieties that were better suited to Canadian agronomic conditions and were more resistant to local diseases than existing varieties

Acknowledgements

Special thanks go to Dr. Frank Marks for his valuable critical review of this section.

Vineland Research Farm
Vineland, Ontario

Lorne W. Stobbs, Research Scientist, Research Branch, Vineland

The Entomological Laboratory was created in 1911 at Vineland Station to study the biology and control of insect pests in fruits. The following year, the Laboratory of Plant Pathology at St. Catharines was established, and research began on plant disease organisms. The two facilities merged in 1960 to become the Vineland Research Station. Over the years, increased emphasis was placed on integrated pest management of diseases and pests, recognizing the growing concern for environmental quality and the need to reduce the use of harmful pesticides. In 1993, the Station was renamed the Vineland Research Farm. Since 2007, the Farm has shared its campus with the Vineland Research and Innovation Centre (VRIC).

The early years, 1911–1985

The current facility at the Vineland site was completed in 1968. The 26-hectare farm on Jordan Road was planted with tree fruits, grapes, berries and vegetables. The Station's staff of 17 conducted research in the fields of plant pathology, virology, nematology and entomology.

Over the years, increased emphasis was placed on integrated pest management in recognition of growing concern for the environment and the need to reduce the use of harmful pesticides. The work included: evaluation of new fungicides and pesticides; the isolation, identification, and characterization of viruses, and studies on how they spread; the development and maintenance of a repository of virus-tested grapes, tree fruits, small fruits and woody ornamentals; the control of soil-born fungal diseases, using biological control agents; and the timing of pesticide applications. Research included the design of an experimental prototype sprayer that allowed the modification and evaluation of droplet size, number, and distribution, as well as output, ground speed and air flow.

The nematology section—the largest such group in Canada—provided information on the fundamental ecological relationships between nematodes and their environments. The group developed novel methodologies for estimating crop loss, assessing nematode populations, determining the efficacy of soil fumigants and nematicides, and characterizing the relationship between the structure of the nematode and its ability to transmit virus diseases.

The Ontario Superior Fruit Stock Program was created in 1972 in support of provincial and federal efforts to produce a nucleus of virus-tested, true-to-name fruit tree stock. The Ottawa raspberry and strawberry certification programs were transferred to Vineland in 1973. In 1979, Vineland became part of a collaborative program with the Ontario Grape Growers Marketing Board and the Horticultural Institute of Ontario to produce virus-free, certified grapevine-propagating materials for nursery propagation and sale.

The beginning of the second century of research, 1986–2011

In the late 1980s, 19 researchers at the Vineland Research Station continued to work closely with the horticulture sector, developing new technologies that contributed to a more sustainable crop protection system.

Entomological research focused principally on sustainable insect-control technologies as part of the larger integrated pest management program.

As concern for the environment became widespread and the cost of pesticides grew, alternative pest management strategies were developed in order to minimize dependency on pesticides. Insect resistance to organophosphate pesticides was identified in orchards, and the rotation of insecticides was shown to reduce resistance buildup.

In 1983, researchers at Vineland discovered that the western flower thrips had arrived in Ontario greenhouses from the U.S. In 1986, these insects were shown to be efficient carriers of the tomato spotted wilt and impatiens necrotic spot viruses associated with heavy disease losses in tomato and ornamental greenhouse crops (particularly chrysanthemums) across the Niagara peninsula. Improved carrier and disease monitoring was implemented using specific petunia varieties while oil, antitranspirants and other biorational products were used successfully to minimize disease spread. Susceptible weeds that could act as virus reservoirs and permit carry-over of virus between crops were also identified.

In 1992, the London Research Centre assumed responsibility for management of the Vineland Research Station, which was renamed the Vineland Research Farm in 1993.

The vegetable and ornamental research programs at Vineland ended in 1997, following Program Review in 1994. Vineland's chemistry section was transferred to London in 1998.

The Harrow pear breeding program, which used conventional breeding methods to improve fire blight resistance, was transferred to Vineland for development of disease-resistant cultivars.

New research emphasized the fit of biorational products, with newer reduced-risk pesticides and integrated pest management, and resistance management programs for tree fruits and grapes. These new pesticides were screened to assess their effect on beneficial insects in orchards so as not to interfere with existing integrated pest management programs.

Plum Pox Virus Research

Research was undertaken in 2000, as part of a national program managed by the Canadian Food Inspection Agency, to eradicate in Ontario and Nova Scotia the plum pox virus (Sharka). This tree fruit disease can have a major economic impact on the production of *Prunus* fruits (e.g. peaches, nectarines, apricots and plums) and ornamental landscaping plants (flowering almond, ornamental cherry, etc.) as well as *Prunus* hybrids. Research was conducted at London, Vineland and Summerland with the objective of improving virus detection and sampling methods, improving understanding of the role that aphids play in the spread of this disease, as well as identifying sources of genetic resistance to plum pox virus for use in breeding programs. Studies on the mapping of virus distribution led to more targeted sampling in field surveys, since the virus was found to be delimited to early season growth in the basal area of stems. Combined with better diagnostic tests, the targeted sampling improved detection of plum pox virus in the field surveys.

In 2002, the Vineland Research Farm became one of the nine Minor Use Pesticides Program (MUPP) test sites established across Canada. The primary MUPP activity at Vineland was the generation of residue and efficacy data to support registration submissions for tree fruits, grapes and vegetables. In addition, research projects focused on insecticides, herbicides and fungicides on peaches, cherries, plums, grapes, apples, and pears. Research was also conducted on vegetables and postharvest storage treatments. Since its beginning, MUPP-related efforts at Vineland have been instrumental in supporting the registration of several pesticides that can be incorporated into the integrated pest management of tree fruits, grapes, and vegetables.

In 2006, two advanced selections from the pear breeding program (subjected to routine virus testing) tested positive for pear decline phytoplasma (*Candidatus Phytoplasma pyri*). Subsequent evaluations of both research orchards and commercial orchards indicated that this phytoplasma disease is widespread in Ontario. Studies are under way in collaboration with the University of Guelph in order to determine seasonal distribution of phytoplasma within infected trees, understand host-pathogen interactions, and identify potential resistance genes.

In response to changes in the fruit production sector following the loss of the domestic fruit processing industry in 2008, pear breeding effort is decreasing and departmental resources are being reallocated to new horticultural research opportunities (including the initiation of an apple breeding and evaluation program) in collaboration with the Vineland Research and Innovation Centre.

Research highlights over the past 25 years

- Showed that an insecticide-resistant strain of the predatory mite *Ambylesius fallacies* effectively controlled the European red mite on a number of fruit crops, and subsequently made the predatory mite commercially available to growers in order to offset the increasing resistance of red mites to acaricides
- Demonstrated that a significant proportion of western flower thrips could pupate within the florets of chrysanthemum, protecting them from control strategies that were directed at the soil
- Demonstrated that economic control of codling moth and apple maggot could be achieved by restricting insecticide sprays to the borders of apple orchards
- Reduced pesticide rates through the development of improved applicators and a better understanding of pesticide activity and persistence
- Developed mathematical models based on the influence of temperature, periods of leaf wetness, and disease development to further reduce the frequency of spray applications
- Achieved early detection of fungicide-resistant strains of pathogens using newly developed molecular methods in crops—in both the field and in storage—that provide a better understanding of disease epidemiology

- Identified many reduced-risk fungicides and a biological control agent for the management of tree fruit diseases
- Developed a novel approach to the control of fire blight in orchards using the bacterium *Pantoea agglomerans* and bacteriophages—microorganisms commonly found in the orchard ecosystem. *P. agglomerans* served a dual role as both a biological control agent and a carrier for the bacteriophages, permitting the continuous production of fresh infective phages on the flower surface while competing with the pathogen for the ecological niche provided by the blossom
- Carried out studies on turnip mosaic virus, potato virus Y necrotic strain, and tomato ringspot virus, which led to the development of resistant varieties and improved diagnostics
- Introduced new fire-blight-resistant pear cultivars for both table consumption and processing, including Harovin Sundown, which features improved fruit quality, regional adaptation, extended harvest and market season, and increased resistance to biotic and abiotic stresses
- Identified a window of susceptibility in peaches—from budbreak to early summer—when oil sprays can be applied to minimize virus spread in the orchard
- Generated plum pox virus-resistant germplasm with established gene-silencing technology; developed biosafety approaches that could be used to produce transgene-free fruits with plum pox virus resistance; and developed a highly efficient and reliable technology for gene transfer in *Prunus* spp.
- Showed hot-water treatment to be an effective means of treating dormant grapevine nursery stock for the control of crown gall disease

In 2007, the Vineland Research Farm, the University of Guelph and the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) joined an industry-led initiative called the Vineland Research and Innovation Centre (VRIC). This private, not-for-profit corporation aims to become a world-class hub of horticultural research and innovation excellence. Responsibility for the AAFC building at Vineland has been transferred to VRIC, but the five Farm researchers continue to conduct research on a range of horticultural issues related to plant pathology, entomology and tree fruit breeding under the authority of Research Branch. In September 2010, the Farm celebrated its 100th anniversary with a special public event. As of 2011, five scientists were conducting research there.

Guelph Food Research Centre
Guelph, Ontario

M. Humayoun Akhtar and James R. Chambers, Research Scientists,
Research Branch, Guelph

A federal agricultural research facility was established in Guelph in 1997 when the food research component and the employees of the Ottawa-based Centre for Food and Animal Research were transferred there. The work of the Guelph Centre was to be closely aligned with the needs of the Ontario food industry, with an emphasis on horticulture and the crops of Eastern Canada. Researchers focus on two main areas: food and health, and food safety. In 2000, this facility became Research Branch's 19th research centre.

The beginning of the second century of research, 1995–2011

The food research component of the Ottawa-based Centre for Food and Animal Research was relocated to Guelph in 1997, following the 1994 Program Review federal budget. Its mandate was to undertake research that was closely aligned with the needs of the Ontario food industry, with a focus on improving food safety and elevating the quality of processed foods.

The new Food Research Program was under the administrative responsibility of the Pest Management Research Centre in London, which was renamed the Southern Crop Protection and Food Research Centre in 1998. The Food Research Program was housed at the campus of the University of Guelph in the former Ontario pesticide laboratories. It remained there until a new food research building equipped with 24 laboratories and a pilot processing plant was opened in June of 2000—as Research Branch's 19th research centre. The Centre operated under independent management, no longer reporting to London, and in 2007 it was called the Guelph Food Research Centre.

People, Facilities and Collaborations: 2000

- A total of 55 employees including 20 researchers
- Molecular Biology Research Unit for studying food DNA, and monitoring and tracking harmful food-borne bacteria
- A food-processing pilot plant
- Located adjacent to the:
  - University of Guelph Research Park
  - Ontario Ministry of Agriculture, Food and Rural Affairs Headquarters
  - Public Health Agency of Canada Zoonoses Laboratories
  - many Canadian and provincial head offices of producer groups and agri-food industry partners
- Worked closely with the University of Guelph and industrial partners such as McCain Foods, the Canadian Poultry Research Council, the soybean growers, and the pork producers of Ontario under various programs, including the Agri-Food R&D Matching Investment Initiative

The new Centre established collaboration between federal and provincial researchers, the Canadian Food Inspection Agency, the University of Guelph, and the Guelph Food Technology Centre. Over the years, the Centre has acquired a reputation for excellence with respect to research on food and health and on food safety.

In the beginning, the Centre's research focused on:

- Microbial food quality and the safety of processing: development of processes for eliminating food-borne pathogens, and of mechanisms to control the growth of pathogens in the food system;
- Chemical and microbial quality and safety of food: development of methodologies for the detection of health promoting minor food constituents; and chemical contaminant residues and food-borne pathogens to ensure food safety; and
- Sustainable practices: development and application of more efficient techniques and processes for the control of food pathogens during food processing.

In 2000, following consultations with federal partners and the food and processing sectors, the research focus turned toward developing and ensuring safe and health-promoting foods that would help reduce health care costs and provide new added-value commercial opportunities. These included mitigating food safety risks in the food production system.

Accordingly, researchers were organized into four multi-disciplinary teams: functional foods and nutraceuticals; food preservation technology, structure and function; and molecular and cellular biology. These teams investigated the relationships between dietary components, human health, and risk of disease, in particular, the extraction and bioavailability of bioactive plant and animal metabolites in foods and dietary fibre.

In 2006, Research Branch released an AAFC Science and Innovation Strategy that positioned Guelph at the forefront of institutions addressing food-related priorities.

In 2011, the Centre was accommodating more than 100 staff, including 21 researchers and visiting scientists and students. Several researchers are adjunct professors at the University of Guelph.

Research highlights between 1995 and 2011

Health and wellness

- Identified and quantified value-added components (e.g. immunity boosters and nutraceuticals) in Canadian-grown agricultural commodities, such as apples, strawberries, potatoes, tomatoes, mushrooms, wheat, soybeans, red clover, flax, and mustard
- Assisted in the development of new varieties of apple (Eden), and strawberry (St-Jean d'Orléans and Clé des Champs)
- Confirmed the functional properties and physiological effects of oat beta-glucan, which substantiated the Canadian health claim that oat fibre helps reduce cholesterol
- Identified barley varieties with a low glycemic index that could serve as rice substitutes
- Identified in natural products a conjugated linoleic acid isomer and trans fatty acid isomers with health benefits
- Developed spectroscopic methods for rapid determination of fatty acids for regulatory purposes that differentiate between desirable and undesirable trans fatty acids and conjugated linoleic acid isomers
- Explored methods that use non-toxic organic solvents for the isolation of active materials from tomatoes and grains
- Solved the earthy-taste problem in potato fries being exported to external markets
- Developed and commercialized a flax dehulling technology to create new health and beauty products for global markets

Food safety

- Developed advanced methods for identification, characterization and enumeration of *Bifidobacteria*

- Studies to control *Staphylococcus aureus*, a pathogen causing mastitis in dairy cattle, revealed an interaction between milk proteins and the phage, a critical determinant of phage therapy efficacy
- Found, while searching for alternatives to antibiotics in poultry production, that mobile genetic elements of *Clostridium perfringens*, a cause of necrotic enteritis in broiler chickens, were responsible for pathogenicity
- Discovered two naturally occurring bacterial strains and developed two effective methods to reduce the toxicity of vomitoxin in cereal grains for animal feeds using these bacterial strains; isolated a chicken-gut bacterium that can anaerobically detoxify vomitoxin, and discovered a soil bacterium that was also found to be useful for aerobic detoxification
- Developed methods to control *Salmonella* in fresh horticultural products

The Guelph Food Research Centre specializes in food safety and nutrition, and is committed to ensuring that food produced in Canada continues to rank among the safest and highest-quality foods in the world. In addition to its focus on food safety, much of the Centre's work centers on exploring the potential of conventional foods to offer nutritional and other therapeutic benefits. Scientists are developing methods to reduce food-borne biological and chemical hazards that may be present in fresh market and processed foods.

Chapter 4, Central Experimental Farm

Ottawa, Ontario
Overview

Central
Experimental
Farm
Ferme
expérimentale
centrale
Canada

Malcolm Morrison, Research Scientist, Research Branch, Ottawa
Dan Schmid, Manager, Properties and Facilities (1996-2008),
Research and Corporate Management Branches, Ottawa
Jean-Marc Deschênes, Director (1998-2001), Research Branch, Ottawa

Located in the heart of Canada's capital city, the Central Experimental Farm is a unique Canadian landmark as well as a vibrant research centre. Created in 1886, the Central Experimental Farm was one of the five original experimental farm stations created by the federal government. It was responsible for administration of the other four. A very popular visitor's attraction with its heritage buildings, its ornamental gardens and its expansive grounds, it is also home to the Canada Agricultural Museum, the Arboretum, and the Fletcher Wildlife Gardens. Over the years, the Central Experimental Farm has witnessed the acceleration of scientific progress at a dizzying pace, but thanks to its own research achievements and the accessibility of its green space to the public, it maintains an enviable reputation in Canada and around the world.

The early years, 1886–1985

In 1886, at the request of John Carling, the federal Minister of Agriculture, William M. Saunders, produced a report whose recommendations formed the backbone of the June 1886 legislation known as *The Experimental Farm Stations Act*.

In his report, Saunders recommended that there be one central station, situated near the capital, central to the important provinces of Ontario and Quebec, with no fewer than 400 acres of land. His view was that "the climate in Ottawa represented the average condition of a large part of the settled portions of Canada, where all the cereals and many other field crops were successfully grown, [where] most of the best varieties of grapes grown in the open air ripened well, and [where] many sorts of apples and other fruits were raised with advantage." Such a station could serve as a central point where all the various classes of experimental work might be conducted.

The Central Experimental Farm (CEF) in Ottawa, originally 188 hectares, grew in size as the demand for land to conduct experiments increased. In 1929, an opportunity arose to purchase the Booth Farm, located directly south of the original farm property. Later, in 1946 and 1949, two additional parcels of land were purchased on the western edge of the Farm, giving the CEF its present land area of 425 hectares. In 1970, the research animals and related activities at the CEF were relocated to the 1,100-hectare Greenbelt Farm, located 14 kilometres from the CEF. This facility was also used to produce animal feed (forages and grain crops) and to dispose of animal waste.

With the creation of Research Branch in 1959, major organizational changes took place, notably the replacement of a structure based on Divisions with one based on Institutes, Research Stations and Research Services. Several reorganizations took place on the Central Experimental Farm between 1962 and 1985, at which time there were five research institutes: Engineering and Statistical; Food; Biosystematics; Land Resource; and Chemistry and Biology; as well as the Animal Research Centre, the Ottawa Research Station and the Research Program Services.

The beginning of the second century of research, 1986–2011
Research Programs

In 1986, the Ottawa Research Station and the Chemistry and Biology Research Institute were merged to create the Plant Research Centre. That same year, the remaining four institutes were renamed research centres. In late 1986, the Central Experimental Farm comprised six research centres, the departmental headquarters, and a large green space.

The CEF's Research Centres: 1986

- **Plant Research Centre (PRC)** had strong breeding programs for corn, soybean, oats, wheat, barley, and forage crops, and had a substantial program in biotechnology and crop protection. PRC also managed the entire Central Experimental Farm, including the research and experimentation site and the green space.
- **Biosystematics Research Centre (BRC)** concentrated on problems related to insects, weeds, and fungi, as well as systematics and identification services. BRC also managed comprehensive collections of plants, insects, and fungi.
- **Engineering and Statistical Research Centre (ESRC)** provided research and expertise in engineering and statistics to improve agricultural and food production and inspection systems, and to support research by scientists from other disciplines.
- **Food Research Centre (FRC)** concentrated on dairy technology, processing technologies, structure and sensory evaluation of food, and the improvement of the quality, safety and nutritive value of food, in order to address the needs of the food industry and the concerns of consumers.
- **Land Resource Research Centre (LRRC)** engaged with Canada's land resources through national programs on Canada's soil inventory system, soil taxonomy and interpretation, soil degradation, land evaluation, crop information systems, and agro-climatic resources.
- **Animal Research Centre (ARC)** conducted research on nutrition, physiology, management, breeding, product quality, disease resistance, and genetics in beef and dairy cattle, swine, poultry, and sheep, as well as food safety and nutrition, and animal waste management.

Between 1989 and 1997, the six research establishments on the Central Experimental Farm were gradually consolidated from six into one. The Engineering and Statistical Research Centre was closed in 1989, with the statisticians transferring to Research Program Services and the engineers and support staff being distributed among other centres, retiring or resigning. The Food Research Centre merged with the Animal Research Centre in 1992 to create the Centre for Food and Animal Research (CFAR). That same year, the Biosystematics Research Centre and Land Resource Research Centre were merged to create the Centre for Land and Biological Resources Research (CLBRR). In 1997, the Centre for Food and Animal Research was closed, and CLBRR merged with Plant Research Centre to create the Eastern Cereal and Oilseed Research Centre (ECORC), which was the only research establishment remaining at the CEF after 1997.

Green space

The CEF is not only a renowned research site. With its heritage buildings, the Canada Agricultural Museum, the Arboretum, the ornamental gardens, and the Fletcher Wildlife Gardens, it is also a popular tourist attraction located in the heart of Canada's capital. In addition, it is the home of Friends of the Farm, 4-H Canada, the Pest Management Centre and the Canadian Dairy Commission.

Following the introduction of horizontal management, in 2002 ownership and maintenance of buildings and land assets were transferred from Research Branch to Corporate Management Branch.

When the CEF was founded in 1886, it was located on the outskirts of the capital, surrounded by farmland. With time, the city grew around the Farm site, and now the CEF is considered to be located in Ottawa, the only capital city in the world to have a working farm within its borders. Many Ottawa citizens view the Farm as a large park where they can walk freely, ride bicycles or admire the gardens. The ornamental gardens and the Arboretum are among Ottawa's biggest tourist attractions. Special events such as open houses and field days are held regularly to inform the public about the research conducted at the CEF and its importance for Canadians.

National Historic Site Designation

The Central Experimental Farm (CEF) was designated a National Historic Site on February 4, 1998. This designation is symbolic of agriculture's important contribution to Canada's social and economic development, and the remarkable role that the CEF continues to play in agri-food research. Following the designation, public consultations on the future of the CEF were held, resulting in the establishment of an advisory council. This body solicits public input and provides advice and recommendations to the Department in its role as steward of the CEF.

Friends of the Farm

In May 1988, members of the public formed Friends of the Central Experimental Farm (CEF), a volunteer organization that helps maintain and improve the public areas of the CEF for heritage reasons and for public enjoyment. Friends of the CEF has been successful since its inception, working closely with the Department to provide expertise and thousands of volunteer hours to restore and rebuild the Heritage rose garden, the Explorer rose garden, the peony beds and the Preston lilacs garden. The Friends were also instrumental in establishing a hosta garden in the Arboretum and in helping expand the collection of peonies bred by William Saunders' son, Percy. The Friends have helped the Department catalogue the trees in the Arboretum, launched a successful tree donor program, and planted more than 700 tree species of interest. The organization has also been instrumental in promoting the CEF as a National Historic Site, thus preserving an important aspect of the Department's heritage. The organization is involved in developing a shelterbelt of trees and shrubs on the western border of the CEF.

Canada Agriculture Museum

The Canada Agriculture Museum dates from 1920 and originally exhibited antique farm equipment. The Department maintained the collection until 1979, when it was transferred to the National Museum of Science and

Technology. In 1983, the latter opened the Agriculture Museum on the top floor of the dairy showcase barn at the CEF. In 1995, the Canada Science and Technology Corporation leased additional buildings, equipment and showcase herds.

The Canada Agriculture Museum offers the public the opportunity to witness aspects of the country's agricultural heritage, to see important breeds of animals, and to learn something about research and the benefits it provides to the nation. The museum was home to the "Haying in Canada" and "A Barn in the Twenties" exhibits in 2011. It showcased a dairy herd, horses, beef cattle, pigs, goats, sheep, and poultry. The museum also offers interpretative public and school programs, and acts as a research resource with respect to Canadian agricultural history.

The Arboretum

Originally established in 1889, the Arboretum covers about 26 hectares and maintains a wide range of well-established trees and shrubs, some dating back to 1889. It represents the oldest legacy of the Department's plant hardiness research. The Arboretum collections contain some 4,000 individual tree and shrub specimens from 56 families. The collections are especially rich in hardy groups such as crab apples, junipers, lilacs, maples, spruces and pines. About 175,000 visitors tour the Arboretum each year.

Ornamental Gardens

The ornamental gardens have been located on the Central Experimental Farm since shortly after its establishment in 1886, and remain a favourite tourist attraction. They were developed out of experimental horticultural plots and consist of annual flowers, a perennial collection, the lilac walks, the rose garden, the Percy Saunders peony beds, the Macoun sunken garden, the iris collections and the hedge collections. The hedge collection was planted between 1891 and 1965 and contains a variety of species. The gardens highlight the work of two well-known plant breeders: Isabella Preston (1920-1946), who was responsible for numerous new flowers and shrubs, including the Preston lilac series, and Felicitas Svejda (1956-1986), who developed many varieties of the Explorer rose series.

Heritage Buildings

In 1997, the Department asked the Federal Heritage Buildings Review Office to evaluate all the CEF buildings to determine their heritage value and the extent of preservation that should be accorded to any of them. As a result of this review, 28 buildings and other structures were designated, including the following:

- The main dairy barn
- The William Saunders Building (named after the founder of the experimental farms)
- The Dominion Observatory, which was the location of some of the work associated with the establishment of standard time in Canada and of the daily official time signal broadcast on CBC Radio
- Part of the main greenhouse range, which has supported the crop breeding programs for many years
- The K.W. Neatby Building, named to honour the founder of Research Branch; it currently houses the main research facilities of the Eastern Cereal and Oilseed Research Centre

Fletcher Wildlife Gardens

The Fletcher Wildlife Gardens were created in 1990 as a project of the Ottawa Field-Naturalists' Club (OFNC) to demonstrate how urban and rural residents can create and enhance wildlife habitat on their own properties and on public properties, and to increase knowledge and understanding of ecology in the Ottawa area and eastern Ontario. The gardens are named after James Fletcher, a founding member of OFNC, who became the first Dominion Entomologist and Botanist attached to the Central Experimental Farm in 1887. After he died in 1908, the OFNC and the Department erected a memorial fountain, which is still located near the gardens.

Key Landmarks and Events

1886: Passage of *The Experimental Farm Stations Act*, which established five experimental farms across Canada

1888: Creation of the Central Experimental Farm with 188 hectares; awarded heritage status in 1998

1889: Establishment of the Arboretum (26 hectares), which contains 4,000 species and welcomes 175,000 visitors each year

1880s: Beginnings of the ornamental gardens that have evolved over the years to include annual and perennial flowers, the lilac walks, the rose garden, the peony beds, the iris collections and the hedge collections

1891: Planting of the old hedge collection, followed in 1965 by the planting of the new hedge collection

1902: Construction of the Dominion Observatory

1920: Creation of the Canada Agriculture Museum, which was transferred to the National Museum of Science and Technology in 1979

1935: Construction of the William Saunders Building

1936: Beginnings of the construction of the K.W. Neatby Building

1967: Opening of the Sir John Carling Building (construction between 1963 and 1966)

1988: Creation of the Friends of the Central Experimental Farm

1990: Establishment of the Fletcher Wildlife Gardens

1997: Designation of 28 CEF buildings as heritage buildings

1997: Creation of the Eastern Cereal and Oilseed Research Centre

1998: Central Experimental Farm was designated a National Historic Site

2009: Move of Headquarters from the Sir John Carling Building to the National Headquarters Complex for the Agriculture Portfolio

Sir John Carling Building

Construction of the Carling Building began in 1963 and was completed in 1966. It opened in 1967 as headquarters for the Department of Agriculture and the offices of the Minister and Deputy Minister of Agriculture. The building was named for Sir John Carling, who was Minister of Agriculture when the CEF was founded in 1886.

In 2009, Research Branch Headquarters moved from the Sir John Carling Building to the National Headquarters Complex for the Agriculture Portfolio, adjacent to the CEF's southwest corner.

Plant and Crop Research
(Eastern Cereal and Oilseed Research Centre)
Ottawa, Ontario

Marc Savard, Research Manager, Research Branch, Ottawa
Jean-Marc Deschênes, Director (1998-2001), Research Branch, Ottawa
Harvey Voldeng, Research Scientist, Research Branch, Ottawa

The history of plant and crop research in Ottawa began in 1886 with the establishment of the Central Experimental Farm. Through the years, scientists produced numerous crop cultivars that had been developed specifically for Canadian agricultural conditions. These cultivars, and their respective genetic traits, have helped to improve yield, quality and disease resistance, to expand the area under production and to add value to crops grown in Eastern Canada. The use of modern informatics and biotechnology tools has greatly accelerated the development of knowledge, genetic materials, monitoring systems and management practices, and has further improved crop production techniques, bioprocesses and bioproducts. Crop breeding using modern techniques, along with the continued development and application of knowledge and technologies to sustainable crop production and protection, are the foundation of plant and crop research programs at the Eastern Cereal and Oilseed Research Centre.

The early years, 1886–1985

Plant and crop research at the Central Experimental Farm (CEF) has been carried out since its establishment in 1886. In the early years, emphasis was on the evaluation of various crop species, on agronomic practices and on breeding, mainly of cereals and potatoes. By the early 1900s, cereal breeding was a high priority, as was research to improve the baking quality of wheat. The CEF is considered the birthplace of Marquis wheat, a variety that represented 90 percent of the wheat grown on the Prairies in the early 20th century.

In the 1910s, evaluation and breeding of forage crops as well as the assessment of production systems such as rotations, forage mixtures and grazing systems were initiated. In the late 1920s, breeding for early maturity, variety trials of soybean and corn, and the breeding and evaluation of lilies, roses, lilacs, crab apples, and chrysanthemums were also undertaken. From the 1920s to 1986, several corn inbreds and soybean cultivars, as well as several standard and hull-less oat varieties, were released. From 1930 to 1959, the research priorities were breeding, genetic evaluation and agronomic practices. In addition, basic research in biochemistry, physiology and pathology provided new knowledge and technologies to support the research.

At the time of the creation of Research Branch in 1959, plant research was divided among research institutes that specialized in genetics, breeding, entomology, botany and microbiology. Re-organization with respect to plant research took place between 1964 and 1973. In 1964, the Ottawa Research Station was created. In 1967, the Cell Biology Research Institute was established, and then integrated in 1971 into the Chemistry and Biology Research Institute. In 1973, the Biosystematics Research Institute was created. In the 1980s, plant research at the Central Experimental Farm was carried out at the Ottawa Research Station, the Chemistry and Biology Research Institute and the Biosystematics Research Institute.

The beginning of the second century of research, 1986–2011

In 1986, the existing Ottawa Research Station and the Chemistry and Biology Research Institute merged into the Plant Research Centre (PRC) bringing together 50 researchers. The mandate of the Centre included developing effective technologies for crop improvement and plant health. Emphasis was given to the development and release of superior cultivars of corn, soybeans, oats, wheat, barley, alfalfa, and forage grasses, as well as biotechnology, which focused on the development and use of new technologies in tissue culture, molecular biology, and cell genetics. The objectives of the biotechnology program were to provide breeders with new and improved tools to develop cultivars and to provide germplasm with increased quality, yield, and resistance to biotic and abiotic stresses. Plant pathologists provided safer and more effective methods of crop protection. PRC also housed the central office of Plant Gene Resources of Canada (responsible for the preservation and exchange of plant genetic resources) until its transfer to Saskatoon in 1998.

In 1986 and 1987, research at PRC was managed in nine sections: genetic engineering, cytogenetics, stress physiology, mycotoxins, plant pathology, symbiotic nitrogen fixation, entomology, cereal crops, and forage crops.

In 1987, PRC conducted an exhaustive review of its past and current activities to determine what kind of research the Centre should conduct in the ensuing 10 years. As a result, the nine original sections were consolidated in 1988 into three programs: biotechnology (molecular technologies), plant-microbe interactions, and plant breeding and management. This structure remained in place until 1996.

The number of researchers at the Centre ranged from 50 in 1986-1987 to 42 in 1995-1996, equally distributed across the three sections. During those years, PRC staff covered a broad spectrum of plant research, ranging from the development and use of new tissue culture technologies to molecular biology and cell genetics, to characterization of plant and microbial genes, to cultivar and germplasm release of corn, soybeans, oats, wheat, barley, alfalfa, and forage grasses.

Cereal breeding remained a key component of research in Ottawa, focusing on both winter and spring wheat until the late 1990s. The soft white winter wheat variety Frederick, developed in Ottawa, occupied more than 90 percent of the wheat acreage in Eastern Canada. Corn hybrid development was terminated in 1986 so that research could be concentrated on inbreds to be licensed to the corn seed industry for the development of their own hybrids.

The Fusarium head blight epidemic of 1981 drastically reduced the yield and quality of the wheat crop in Eastern Canada. Fusarium head blight produces mycotoxins that significantly reduce the yield and quality of wheat, barley, and corn, and in addition, contaminate animal feed. Contaminated cereals fed to animals, especially pigs, cause serious health problems, and decontamination is very costly and impractical. To address this problem, the Department invested significantly in research to characterize Fusarium toxins, understand the epidemiology of the disease, and develop varieties with resistance to the fungus.

The CEF has been the site of a number of firsts for genetically modified organisms. The first field release of a genetically modified microorganism took place there in 1991 with the release of a beneficial *Rhizobium meliloti* strain that had been genetically marked with dormant DNA from another bacterium. In 1995, soybean plants containing the oxalate oxidase gene were evaluated for the first time in Canada in a confined field trial at the CEF. This gene provides partial resistance to the fungal pathogen *Sclerotinia sclerotiorum*, which is responsible for Sclerotinia, a white mold infection of numerous crops, such as soybean, canola, and white or navy bean.

In 1997, the Eastern Cereal and Oilseed Research Centre (ECORC) was established through the amalgamation of the Plant Research Centre and the Centre for Land and Biological Resources Research. From 1997 to 2011, the mandate of ECORC, in terms of plant research was to continue to develop improved crop varieties as well as integrated agronomic systems for crop production and protection. The Centre was organized into three sections (crop development, molecular technology and land/agronomy) whose work included:

- Developing new soybean varieties and corn inbreds for short-season areas of Eastern Canada;
- Developing higher-quality cultivars of winter and spring wheat, oats and barley for Eastern Canada with improved yield, early maturity, and resistance to diseases (e.g. Fusarium) and insects;
- Determining best crop management practices, such as minimum tillage and the improved use of organic nitrogen;

- Determining fertilizer needs of crops, optimal crop rotation, and cultivation methods to reduce soil erosion;
- Studying the interaction between plants and pathogens, and the effects of agricultural practices on crop diseases;
- Isolating, characterizing, and using useful plant genes to add product value, reduce environmental impacts on crops, and increase resistance to insects and diseases;
- Identifying molecular markers associated with important crop traits to genetically enhance crops;
- Identifying sources of resistance to Fusarium and using these to improve the genetic resistance of wheat, barley, and corn; and
- Developing innovative, value-added technologies to isolate and purify new compounds from plants, seeds, and other organisms.

Research areas

Breeding

Wheat

Eastern Cereal and Oilseed Research Centre (ECORC) scientists continued the breeding and genetic improvement of winter wheat, including the development of the first Fusarium-resistant cultivar in North America (FT Wonder). Further research led to the identification of molecular markers associated with Fusarium resistance genes in the wheat genome, which are used in the selection for Fusarium resistance in the wheat breeding programs. Some Fusarium-resistance genes are also being introduced from wild wheat species, such as *Triticum monococcum* and *Aegilops speltoides*.

Spring wheat breeding for Eastern Canada was conducted primarily at the Charlottetown and Sainte-Foy research stations between 1970 and 2000. By 2004, however, these breeding programs were combined with a rejuvenated spring wheat program at the CEF, with emphasis on quality and Fusarium-resistant cultivars. The cultivars Hoffman and Fuzion were released from these programs.

Oats

Historically, oats were grown mainly for animal feed, but have become increasingly important for human food nutrition. Oat research increased with the signing of an agreement between the Department and Quaker Oats, which lasted from 1989 to 2006. This agreement involved a number of organizations including Cornell University, the University of Minnesota, Iowa State University, the University of Saskatchewan, as well as other oat laboratories in the U.S., Wales and Brazil. The research collaboration with Quaker Oats has led to the release of three covered oat varieties in Eastern Canada and the development of a new high-milling-quality oat, which contributed to the reopening of the Quaker plant in Peterborough. Through this collaboration, a number of key oat genes were tagged, and the first molecular recombination map of cultivated oat was developed, resulting in marker-assisted breeding and the development of a new high-throughput genotyping platform for oats in 2009. Oat breeding has also focused in the past decade on the development of naked or hull-less oats and produced nine varieties including AC Gehl. This variety has attracted interest for application in new and emerging markets (including the recreational and thoroughbred horse feed market), for production of pure oats for celiacs, and as a rice replacer in whole oat products including "Rice of the Prairies"® and a precooked meal by Campbell Canada called "Nourish"®.

Greenhouse Facilities

There have been several greenhouse complexes constructed on the Central Experimental Farm (CEF) since 1886. Many of these facilities were in use for more than 100 years, expensive to maintain and not energy-efficient.

In November 2009, a new integrated growth facility, consisting of state-of-the-art greenhouses and a number of growth chambers and growth rooms, was opened at the CEF. This facility greatly improved the ability of Eastern Cereal and Oilseed Research Centre researchers to produce better results, with the superior control of temperature, humidity, light and biological contaminants.

Natural-product research on oats revealed that they contain a unique series of compounds for which the name avenanthramides was coined. These avenanthramides were found to be the source of the well-known anti-irritant, anti-itch properties of soothing oatmeal baths and personal care products. The structures and additional bioactivities of these compounds as dietary anti-inflammatory agents were elucidated, and further research indicated that they may play a role in arresting the progression of cardiovascular disease. These studies provided additional indications of the potential health benefit of oat consumption in the prevention of coronary heart disease beyond its known effect of lowering blood cholesterol.

Barley

Barley research at ECORC addressed both two-row and six-row barley, with emphasis on breeding techniques, such as doubled haploidy and callus-derived regeneration from both microspores and somatic cells, and the development of standard and hull-less barley cultivars. Breeding for Fusarium resistance was as important for barley as it was for wheat. Development of cultivars resistant to barley yellow dwarf virus was also undertaken.

Corn

The corn breeding program focused on disease resistance, notably Fusarium resistance, earliness for short, cool regions, and combining ability for hybrid yield. The program has been very successful in recent years. Since 1986, 260 corn inbreds have been released to industry, most of them exhibiting improved resistance to Fusarium infection and disease and insect pests, as well as high combining ability.

The corn research team has developed internationally recognized rapid screening techniques for corn diseases such as northern corn leaf blight, rust, eyespot, smut, Fusarium stalk rot, and anthracnose stalk rot. Furthermore, a selection of the most important departmental corn inbreds has been studied for their resistance to eight major corn diseases to help commercial companies more easily determine how to use the inbreds in their breeding programs.

Soybeans

The soybean program has had considerable success in breeding soybeans for the Asian natto market, by developing several cultivars adapted to the climates of Quebec, Ontario and Manitoba. Natto soybeans are much smaller than standard ones, so the fermentation process required to produce the desired product is more effectives. The soybean program has also been very successful in developing short-season soybean cultivars of both food and feed types. Other important traits incorporated into new cultivars include high protein content and pest resistance. These cultivars have significantly expanded soybean acreage in eastern Ontario, Quebec and Manitoba. For instance, in Quebec, the acreage grew from 4,400 hectares in 1986 to 261,000 hectares in 2010; in eastern Ontario, from 167,300 hectares in 2003 to 249,700 hectares in 2008; in Manitoba, from 7,290 hectares in 1998 to 206,400 hectares in 2010; and in the Atlantic Provinces, from 2,300 hectares in 1986 to about 21,000 hectares in 2010.

Soybean isoflavones have multiple health benefits due to their structural similarity to mammalian estrogen, and their levels are significantly higher in the newer varieties.

Pathology

Researchers have studied a number of plant diseases. Fusarium research has been a high priority, focused on breeding for resistance and on developing procedures for the rapid testing of resistance in cereals. ECORC has also established a Fusarium mycotoxin-testing laboratory. This laboratory now processes between 16,000 and 19,000 samples of grain every year for departmental cereal breeders from all over the country. The Fusarium nurseries have been very successful at identifying resistant genotypes of winter and spring wheat, barley and maize, which have been used as parents in the breeding program. Work has been ongoing to produce new biological control formulations for the control of fungal diseases.

Molecular biology

Molecular biology techniques have contributed to the knowledge required for breeding superior crops at ECORC via gene discovery, regulation of gene expression, and the development of enabling technologies. These technologies and knowledge have been used to modify plant constituents, to facilitate gene transfer in plants, and to control gene flow between transgenic crops and related wild species.

Agronomy

Research on the use of nitrogen fertilizer, conducted in collaboration with the University of Guelph and the Ontario Ministry of Agriculture, Food and Rural Affairs, has contributed to steadily increasing corn yields with reduced fertilizer consumption. In addition, research has helped scientists to gain a better understanding of dry-matter accumulation, grain and silage moisture change, and carbon and nitrogen balance, and has led to the production of better silage-specific corn hybrids as a result.

Grain Quality

Oat dehulling was always an arduous process. By modifying a wringer dehuller, ECORC researchers were able to measure the energy required to dehull a single oat kernel. This has facilitated a better understanding of the differences between genotypes, which in turn will improve the selection of more easily dehulled oat varieties.

Near-infrared technology has also been very useful for the evaluation of a number of cereal and oilseed characteristics, from basic grain components such as protein and oil content to beta-glucan (ß-glucan) levels in oats and barley, and has lent great support to the breeding programs.

Research highlights over the past 25 years

- Between 1986 and 2010 at PRC and ECORC, developed 65 cereal cultivars (19 standard oat, 7 hull-less oat, 23 barley, 14 winter wheat, 2 spring wheat), 55 soybean cultivars (including 17 natto—

the first in Canada—and 5 tofu lines (food-grade soybeans for export market), and 260 corn inbred lines

- Developed short-season soybean varieties and corn inbreds that withstand cooler temperatures, thus expanding the farming frontier in Ontario, Manitoba and Quebec, as well as hull-less oats varieties that attracted new markets as rice replacement for food and high-end animal feed
- Elucidated the genome of *Fusarium graminearum*, the main species causing Fusarium head blight in North America
- Developed immunological methods using monoclonal antibodies to quantify deoxynivalenol in infected cereal grains, allowing rapid and inexpensive testing of large numbers of wheat, barley, corn, and oats experimental lines for Fusarium resistance; the monoclonal antibody was licensed for commercialization
- Identified several soft white winter wheat lines resistant to Fusarium head blight and used them to develop resistant cultivars, including FT Wonder, the first in North America
- Established a national mycotoxin facility to identify, detect and purify mycotoxin levels in food and animal feeds, help scientists monitor and study the disease caused by *Fusarium graminarum*, and guide breeding research in the development of resistant cereal and oilseed cultivars
- Showed significant genotype interaction and identified three distinct mega-environments in Eastern Canada (northern Ontario, southern and eastern Ontario, and Quebec and Atlantic Canada) through the statistical analysis of oat-yield trial results
- Patented a new bio-fungicidal agri-product (ACM941-CL01) in the U.S. and Canada for the control of Fusarium head blight in wheat, foliar diseases in greenhouse vegetables and fruits, and soybean and cereal root rot
- Developed a new instrument combining microscopic optics and digital image processing to automatically measure bran contamination, starch damage and fibre content in cereal grains

- Developed a micro-spectrophotometric method with great commercial potential to measure germ content in wheat flour
- Showed that new soybeans in the short-season region increased yield by 25 percent and had up to 58 percent more isoflavones than varieties developed over 50 years ago
- Produced soybean plants containing a gene expressing oxalate oxidase that provides resistance to white mold
- Precisely identified *Rhizobium* strains released to industry using insertion sequence fingerprinting
- Released a genetically engineered beneficial *Rhizobium* strain and monitored it in the field to allow the Canadian Food Inspection Agency to draft regulations governing the release of such microorganisms into the environment
- Developed a rapid procedure using polymerase chain reaction to detect barley yellow dwarf virus in leaf extracts of infected oat and barley plants
- Devised a unique approach to modifying the protein composition of pollen coats of plants that could be used to generate hybrid seeds and prevent unwanted gene flow; developed methods to control seed germination in transgenic plants to prevent the uncontrolled spread of novel traits; this two-component genetic system was tested in tobacco and received worldwide media attention
- Determined that gene-regulating sequences in various floral organs isolated and tested in transgenic canola can be used to express heterologous genes in specific organs; these findings make it possible to develop tools to control fertility in transgenic plants as well as a mechanism for hybrid seed production
- Modified corn using recombinant DNA biotechnologies to increase the development and production of cereals with novel traits; held the first Canadian public confined field trial for this modified corn in Ottawa

Plant research at the CEF has had a long history of success, dating back to the first research establishment at the Farm in 1886. Among the major achievements are the numerous crop cultivars that have been developed and registered over the years—more than 100 cultivars of cereals and soybeans and more than 260 corn inbred lines since 1986. All of these cultivars with their respective genetic traits have contributed to improving yield, quality, and disease resistance, have expanded the area of production, and have added value to crops grown in Eastern Canada. The use of modern informatics and biotechnology tools has greatly accelerated the development of knowledge, genetic materials, monitoring systems, and management practices that will further improve crop production, bioprocesses, and bioproducts. Crop breeding using modern techniques, as well as the continued development and application of knowledge and technologies to sustainable crop production and protection, and the development of value-added products, remains today the foundation of the plant and crop research programs at the Eastern Cereal and Oilseed Research Centre.

ECORC has a staff of 320 employees including 80 researchers. As well, fifteen retired honourary or emeritus scientists work on their own time. ECORC has access to the CEF's 425-hectare farm for experimental fieldwork. The Centre manages a national bioinformatics network with capacity for functional and structural genomics, including a high-performance computing cluster, as well as a central genomics facility. The Centre manages the Department's electronic microscopy and nuclear magnetic resonance centre.

Since 1997, the Eastern Cereal and Oilseed Research Centre has continued to conduct research in plant science, but also in land resources and biosystematics.

Land Resource Research
(Eastern Cereal and Oilseed Research Centre)
Ottawa, Ontario

Ted Huffman, Research Scientist, Research Branch, Ottawa
Jean-Marc Deschênes, Director (1998-2001), Research Branch, Ottawa

Land resource research at the Department dates back to the founding of the Central Experimental Farm in 1886. In the early years, the focus was on surveying and mapping Canadian soils. Later, the research diversified to include soil chemistry and mineralogy, land use and evaluation, agro-meteorology, and computerization of soil and land data. In recent years, the scope of research has expanded to encompass work related to biodiversity, climate change, and soil, water, and air quality, all using current technology such as satellites and powerful computer systems. Environmental pressures arising from agriculture—the growing awareness of the need to preserve air, water, and soil quality as well as biodiversity—have become a greater concern. Research to reduce agricultural risks and improve the health of air, water, and soils provided the tools that farmers needed to make informed land-use management decisions and maintain the health of the agricultural environment.

The early years, 1886–1985

Interest in studying soil in Ottawa began with the establishment of the Central Experimental Farm (CEF) in 1886. Emphasis during the early years was on soil chemistry, which culminated in the creation of the Soil Chemistry Division, and on soil surveys. The Soil Research Institute (SRI) was created in 1959 and renamed the Land Resource Research Institute (LRRI) in 1978.

Between 1920 and 1935, soil surveys were conducted in the Prairie Provinces with the financial support of the new *Prairie Farm Rehabilitation Act*. In the late 1930s, the surveys were extended to other provinces. In the early 1940s, contributions made by the federal government came from Experimental Farm services.

Between 1945 and 1960, soil surveys in Canada were nationally coordinated. The first Canadian taxonomic system of soil classification was outlined at the third meeting of the National Soil Survey Committee in 1955. From 1960 to 1975, soil surveys evolved to include the use of a refined soil classification system and an agricultural capability interpretation for Canadian soils, which was a component of Canada's land inventory program. The Soil Resource Inventory Section was created to aid in correlating and supporting the national soil survey program. In 1973, this section began to develop the computerized storage system for soil survey, soil management, potential yield, and cartographic data that is known today as the Canadian Soil Information Service.

In all, more than 300 million hectares covering 35 percent of Canada's land mass were surveyed between 1920 and 1974 (including 50 million hectares that were mapped). More than 200 soil maps were drafted and published. Between 1974 and 1985, the Soil Resource Inventory Section managed the national soil survey program and its seven regional soil survey units (Truro, Nova Scotia; Sainte-Foy, Quebec; Guelph, Ontario; Winnipeg, Manitoba; Saskatoon, Saskatchewan; Edmonton, Alberta; and Vancouver, British Columbia), and the correlation and database services in Ottawa. In 1985, the number of soil survey units was increased to 11 with the addition of teams in St. John's, Charlottetown, Fredericton and Whitehorse. The survey teams moved to a fully digital environment, which was subsequently recognized as an important precursor of Geographic Information Systems (GIS). There were also activities directed toward the improvement of survey techniques, the enhancement of the computerized databases, the development of a new soil capability rating system, and the development of a generalized and harmonized Soil Landscapes of Canada map.

At the end of the first 100 years of federal agriculture research, land research in Ottawa included an environmental chemistry program focused on developing methods for detecting and extracting bound pesticide residues, determining the fate of those residues in soils and plants and studying the interactions between soil organic matter and mineral components as well as a program on clay mineralogy and land evaluation. The Land Resource Research Institute operated mineral and chemical analysis services for the Department as well as for public and private sector researchers.

The beginning of the second century of research, 1986–2011

In 1986, LRRI was renamed the Land Resource Research Centre (LRRC). Studies in soil quality, erosion, conservation, mineralogy and organic matter, land evaluation, the fate of pesticides, climate and weather, crop growth, meteorology and remote sensing continued to be the essential activities of the Centre. At the same time, the inorganic-organic soil interaction study was terminated, the analytical chemistry laboratory was grouped with computer facilities under a new services section, and a soil conservation engineering study was launched. The Centre had 80 researchers, including 42 regional soil surveyors.

The new century also saw the beginning of integrated, landscape-based research carried out in concert with several international agencies and with the support of various partners, including Environment Canada. Research was directed toward improved understanding of the interactions of soil and climate, the development of new technologies for the classification, mapping and interpretation of land use, and the development of measures to estimate regional crop production. This was the beginning of multi-disciplinary studies in agro-meteorology. Computer technology in the form of the Geographic Information System, mathematical models, and analytical spreadsheets and databases was developed to study production risks and environmental impacts, the results of which formed the basis for ongoing Canadian contributions to reports of the Intergovernmental Panel on Climate Change and to the United Nations Framework Convention on Climate Change.

The Centre continued to oversee the national soil inventory (soil survey and mapping) and soil information management. Canadian Soil Information System staff prepared soil maps and databases, and responded to requests for assistance in interpreting data and generating products such as pest risk maps, pesticide dissipation maps and official plans.

Collaboration with Statistics Canada

A major initiative involved cooperation with Statistics Canada to develop a module for the Agricultural Census to monitor the extent and location of soil conservation practices on Canadian farms.

Research activities were regrouped under three programs in 1991: national and regional land resource data and applications; sustainable land productivity; and environmental quality. This reorganization resulted in increased emphasis on the development of standards for data collection, management and application, and the enhancement of production of the national generalized Soil Landscapes of Canada map. This map was the primary framework for landscape-based soil, water and air quality research in the Department.

In 1992, the soils and land program became the Land Resource Division of the newly created Centre for Land and Biological Resources Research (CLBRR), while the provincial and territorial soil survey units became land resource units. This structure remained stable until the end of 1994. Soil inventory work continued, particularly in Alberta, Saskatchewan, Manitoba, and Quebec, but more emphasis was being placed on upgrading old surveys, maps, and databases in order to improve accuracy and add information not previously available. In 1992, more than two million hectares of land in Saskatchewan, Alberta, Quebec, Ontario, and New Brunswick were mapped.

The sustainable land productivity program continued to develop standards and criteria for soil quality assessment, establishing field sites to collect wind erosion and salinization data, and to predict the effect of climate change on crop production. In addition, a framework for evaluating sustainable land management was developed in collaboration with the United Nations Food and Agriculture Organization. The environmental quality program continued field studies to characterize water and solute movement in soil, to quantify agricultural-atmospheric interactions, and to isolate the impact of soil microorganisms on the fate of pesticides.

The 1994 Program Review resulted in the realignment of soil programs toward regional issues. This led to the transfer of the reporting relationship of all provincial and territorial soil survey units from Ottawa to the regional research centres. Each of these units—renamed land resource units—focused on developing applications and technologies to serve regional client needs. That same year, the Department abandoned a long-term soil quality benchmark initiative, and national correlation and coordination activities.

Agro-Meteorology

The early 1990s saw an intensive study in agro-meteorology launched under the Environment Canada Green Plan, with emphasis on correlating climate with agricultural production. In 1993, the Centre became the departmental lead in the development of agri-environmental indicators, and for an initiative on agri-environmental indicators led by the Organization for Economic Co-operation and Development. The first report in 2000 included 14 indicators related to soil, water and air quality, biodiversity and production intensity, covering the period from 1981 to 1996 and relying heavily on interpolated Census of Agriculture data. The indicators program was subsequently named the National Agri-Environmental Health Analysis and Reporting Program, which has since become a world leader in the development and reporting of agricultural and environmental indicators.

In 1997, the Plant Research Centre and the Centre for Land and Biological Resources Research were merged and named the Eastern Cereal and Oilseed Research Centre (ECORC). Researchers in the soil/land program focused their attention on the impact of land management on soil, air, and water quality.

Increased computing capacity and more powerful Geographical Information System and database software enabled the development of increasingly detailed soil, climate, and land management databases, as well as more powerful models to assess greenhouse gas emissions, soil carbon, and nitrogen changes, and climate change mitigation and adaptation scenarios. Remote sensing for land use and land cover mapping, identification of management zones for precision farming, identification of stresses on crops, and estimation of greenhouse gas fluxes over agricultural targets became important areas of research. These research activities led to the development of the Model Farm and the publication of *The Health of our Air—Towards a Sustainable Agriculture in Canada in 1998*. The Canadian Soil Information System maintained its emphasis on national databases and service to national programs through correlation and harmonization of data and procedures across the provinces and territories. The Canadian Land Resource Network was formed at this time as an informal vehicle to maintain communication and collaboration among soil and land specialists in Canada.

Following the implementation of the Department's new governance structure, in 2002 Research Branch re-organized its activities into national research themes. A land resource inventory program under the Environmental Health National Program and the establishment of a soils theme meant instituting a nationally coordinated work planning structure, as well as soil interpretation and land use programs. In 2004, the third version of the Soil Landscapes of Canada map series, a soil carbon map for Canada and North America, and a map of the peat lands of Canada were published. No new extensive soil mapping was conducted at the federal level at that time.

In 2005, most of the land resource inventory staff, both those with the Canadian Soil Information System unit in Ottawa and those in regional units, were assigned to the National Land and Water Information Service (NLWIS). NLWIS was a project to bring together all the information collected over the years by the soil survey and land resource teams and to make it accessible online. In late 2009, upon completion of the National Land and Water Information Service project, soil specialists and support staff were reassigned to high-priority research within Research Branch, such as ongoing projects related to climate change and water quality. Most of the remaining regionally based pedologists linked to land resource activity were transferred to the new Agri-Environment Services Branch, along with the Canadian Soil Information System and its data holdings. Here they became responsible for supporting the development of agri-geomatic products and services, such as web-based agri-geomatic solutions, interactive soil mapping applications and Geographic Information System data management.

Research highlights over the past 25 years

- Developed methods to identify crops using a combination of optical and radar imagery; these methods are now being used to map crops across the Prairie Provinces
- Determined that soil moisture, percentage of crop residue cover, crop biomass accumulation, and yield can be estimated using satellites
- Supported regulatory action for the continued application of biosolids as fertilizers, especially using new injection technologies, based on studies of the effects of fecal pollution sources, manure, and pharmaceuticals on watersheds and waterways
- Developed methods to measure soil water content that greatly improved water management; these have been adopted worldwide
- Published the ecostratification framework in 1996. Comprising ecodistricts, ecoregions and ecozones, it is one of the most comprehensive large-area hierarchical spatial frameworks in the world and is the spatial basis for most federal agricultural environmental and production studies
- Showed through remote sensing research that satellite technology could classify crops to 30-metre resolution at 88 percent accuracy, and could precisely estimate the sizes of fields in complex landscapes
- Documented pesticide movement in soil and lake sediments, and developed software to assist in identifying manure disposal options to prevent groundwater contamination

- Developed economically feasible methods of assessing the associations among greenhouse gas flux, soil characteristics and management practices
- Increased computing capacity; more powerful Geographic Information System software and database software have enabled the development of increasingly detailed soil, climate and land management databases, as well as more powerful models to assess greenhouse gas emissions, soil carbon and nitrogen changes, and climate change mitigation and adaptation scenarios

Reducing agricultural risks and safeguarding the health of air, water and soils are the Department's main research focuses. With respect to air, the priority areas are particulate emission, odours, and the emission of gases that contribute to global warming. Water quality and management entails studying the effects of fecal pollution sources, and the effects of land application of manure and biosolids on the quality of watersheds and waterways, while the focuses for soil research are soil organic matter, and soil erosion caused by water, wind, and tillage. Researchers are using satellite images to better understand soil characteristics and growing conditions. Finally, agro-meteorology activities are focusing on crop production footprints and greenhouse gas emissions from agriculture. New knowledge and technologies in these areas provide the tools that farmers need to make informed land-use management decisions and to maintain and enhance the health of the environment and natural resources associated with agricultural production. The research currently conducted at ECORC on climate change, water quality and management, and soil quality is addressing these key priorities.

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Food Research
Ottawa, Ontario

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Before the creation of the Food Research Institute in 1962, the Department's food research was carried out under the Division of Horticulture and focused mainly on the storage and preservation of food. In 1986, the name of the Food Research Institute was changed to the Food Research Centre, and in 1992, food research was integrated into the program of the Centre for Food and Animal Research. Over the years, food researchers have made significant contributions to the acquisition of knowledge and the development of technologies in food processing for dairy products, food crops and meat, food quality and safety, and human nutrition. Numerous research findings have been patented and commercialized by the Canadian food industry. In 1997, food research was transferred to the organization in Guelph that was to become the Guelph Food Research Centre two years later.

The early years, 1962–1985

Prior to the creation of the Food Research Institute in 1962, food research in Ottawa mainly focused on the storage, preservation and processing of food crops under the direction of the Horticulture Division. In the 1960s, the establishment of the Food Research Institute resulted in a significant increase in resources and facilities, such as processing laboratories, as well as the expansion of food research programs. Ottawa food scientists and engineers in collaboration with colleagues in Nova Scotia, Manitoba, Alberta and British Columbia solved a number of preservation problems and improved many processes, resulting in increased returns to primary producers and a greater variety of higher quality foods for consumers. Of particular interest were the development of a technique to rapidly freeze homogenized and pasteurized liquid eggs, and a method to extract a protein from canola that is an acceptable food for humans as well as livestock.

In the mid-1970s, Food Research Institute's research programs were concerned with the development of methods that allowed optimum utilization of Canadian agricultural raw products for food, notably the processing of crops such as rapeseed and mustard seed, wheat, buckwheat, beans, and potatoes, and the quality control and preservation of milk and dairy products.

In the early 1980s, Food Research Institute's research continued to make substantial progress in the areas of food quality, food safety and nutrition, and new food ingredients (oats, oilseeds). Of particular interest were the functional properties of food (wheat, meat) proteins, oat fractionation and the functional assessment of those fractions, the phenolic constituents of cereals and oilseeds, the analysis of glucosinolates in crucifers, further improvement of the sensory evaluation program, and the development of a nutrient database for Canadian fruits and vegetables. Food Research Institute also administered contract research programs, such as one involving the dairy industry.

The beginning of the second century of research, 1986–1997

In 1986, the Food Research Institute was renamed the Food Research Centre and given a mandate to help the Canadian food and beverage industry become more efficient, productive and competitive, by developing new and improved processing technologies and ingredients, and by improving the quality, safety and nutritional value of food. Increased emphasis was placed on activities to transfer technology to industry, on collaborative long- and short-term research projects, and on the increased participation of the private sector. This was to be achieved by developing new and improved processing technologies for cereals, oilseeds and dairy products, and by improving the quality, safety and nutritive value of food.

Sensory Evaluation

The Centre's well-equipped sensory evaluation lab and trained sensory panels played important roles in testing the effects of meat, dairy and plant-derived food production and processing on end-product quality. Evaluation was conducted for a number of departmental researchers, as well as for private sector clients.

Considerable expertise was acquired in the structural biochemistry, functionality and process engineering of oats as a Canadian crop with value-added potential. Important progress was made on the identification of physico-chemical properties of oat β-glucan, and on its analysis and preparation for human clinical trials, as well as on the structural elucidation of anti-inflammatory oat avenanthramides. The functional properties and potential uses of oat globular protein, alone and with meat, poultry and dairy formulations, were the subjects of collaborative studies. The chemical bases of off-flavour and astringency in milk were evaluated, as were the effects of thermal processing on the functionality and ultrastructure of dairy proteins. FRC also provided research and advisory services, and managed numerous research contracts.

Between 1987 and 1991, the Food Research Centre had 22 researchers. During this period, the four original research programs (processing technologies, dairy, structure and sensory evaluation, and food safety and nutrition) were reorganized to better address the national and regional needs of the food industry. To that end, the (cereals) processing technology program was relocated to the Saskatoon Research Centre, dairy was reduced but retained three researchers, food safety and nutrition became separate programs with five and nine researchers respectively, and a new food quality program was developed, with five researchers covering structure and sensory evaluation.

Soluble Dietary Fibre

Between 1992 and 1997, collaboration with clinical researchers on the structural features, physico-chemical properties and molecular weight profiles of cereal beta-glucans (ß-glucans) improved the understanding of observed structure-activity responses and the potential nutritional benefits of soluble dietary fibre. Microscopy studies on whole and sectioned oat kernels showed that the distribution of oat ß-glucan was largely localized in the bran region of the grain.

In 1992, Food Research Centre merged with the Animal Research Centre to form the Centre for Food and Animal Research. Food research was refocused toward the development of methods for assessing and enhancing the safety, quality, and nutrition of foods, and included some new elements of expertise in animal feed safety and nutrition. The food program had specialized facilities for the sensory and instrumental evaluation of food, for food microstructure research, and for pilot plant processing.

The 1994 Program Review determined that food research conducted in Ottawa would be transferred to Guelph. Research was pursued until the closure of the Centre for Food and Animal Research and the transfer of the food program and the research team to Guelph in 1997.

Research highlights between 1986 and 1997

Processing technology

- Developed and patented technologies for oat processing, resulting in the clean separation of bran and endosperm and the recovery of enriched fractions of oat starch, soluble fibre, protein and antioxidants
- Developed and patented techniques for producing value-added components from pork blood that could be reformulated with milk-based compositions as an auto-immune-boosting feed component for neonatal pigs

- Carried out a collaborative study with a probiotics company that led to the development of a stabilized flour containing high levels of soluble dietary fibre
- Modified a continuous process for the production of ricotta cheese that was then incorporated into the production of tofu from soybean milk and commercialized

Dairy technology

- Developed predictive models based on milk composition to determine cheese yields and pricing formulae for specialty milks, butter and powdered dairy products; the models were then tested and validated in milk processing plants, allowing for more accurate pricing of raw dairy ingredients

Food safety, quality and nutrition

- Developed new techniques for distinguishing and monitoring the performance of the industrial bacteria used in starter cultures for meat and dairy fermentations
- Determined the critical mineral nutrient and vitamin contents of fresh and processed potato products, which were used to update the Canadian Nutrient File and national food guide recommendations
- Showed, using microbiological evaluation of pasteurization procedures for milk and liquid egg products, the potentially inadequate destruction of *Listeria monocytogenes*, a pathogenic bacterium causing listeriosis in humans, farm mammals and poultry; using pilot plant facilities at CFAR, scientists developed viable processes to ensure the safety of milk and liquid egg products; predictive-modeling software was developed for risk assessment
- Performed human trials—the first of their kind—that showed that oat beta-glucan (β-glucan) lowers postprandial plasma glucose and insulin response in a dose-dependent manner, and that it may be beneficial in regulating metabolic responses in Type II diabetics

- Revealed unique thermal properties and flow characteristics of oat proteins that present opportunities for the development of new ingredients and products for food, feed and industrial uses
- Developed novel techniques using microwaves for the sample extraction of antibiotic and pesticide residues

Structure and sensory evaluation

- Enhanced efforts to elucidate and evaluate the roles of physical texture and microstructure in food quality assessment via microscopy and ultra-structure research capacity

Biosystematics Research (Eastern Cereal and Oilseed Research Centre) Ottawa, Ontario

Yolande Dalpé, Research Scientist, Research Branch, Ottawa
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Biosystematics research, which is the study of the variation, evolution and classification of living organisms, was instituted as early as 1886 to respond to the needs of a variety of stakeholders in government, industry, academia and among the general public. Over the decades, researchers have increased biosystematics knowledge and their findings have been used to classify living organisms, to discover, describe and identify beneficial, invasive and parasitic species, and to provide stakeholders with effective biological tools for problem solving. Collections and herbaria were used to amass knowledge and preserve the country's biological heritage. They represent unique and irreplaceable national treasures that can survive and evolve through biosystematics research and the application of that research to the development of agriculture and the preservation of the environment.

The early years, 1886–1985

In 1884, Mr. James Fletcher was appointed by the government as Honourary Entomologist for the Department of Agriculture and was asked to advise on appropriate action to prevent imported insects from becoming serious problems in Canada. Since 1886, with the development of the experimental farm system, the expertise and influence of the Department's biosystematists have grown.

The Division of Entomology and Botany, originally a single entity, split in 1908 to give rise to the Division of Entomology and the Division of Botany, these ultimately becoming the Entomology Research Institute and the Botany Research Institute, respectively, in 1959. In 1973 they merged again to become the Biosystematics Research Institute.

Between 1974 and 1985, biosystematics research was organized into three main sections.

- Vascular plants: This section dealt with the systematics of plants, notably those used as field crops, such as crucifers, pulses and cereals. Research in this domain also included the study of weeds and indigenous flora, aquatic plants, sedges, and grasses.
- Mycology: Much of the mycological research focused on the systematics study of fungal parasites, forage and fruit tree parasites, the taxonomy of fungi responsible for diseases that attack Canadian crops, notably parasitic agents causing rusts, smuts, blights, and wood decays, and the taxonomy of macroscopic, edible, and poisonous fungi. During the 1980s, the traditional areas of research were expanded to include applied work to improve agricultural production and to protect plants, and, specifically, the biosystematics of bio-pesticides, mycorrhizal biological fertilizers, and mycotoxin-producing fungi.
- Entomology: The entomology section was divided into subsections either based on taxonomic groups (insects, arachnids, mites and nematodes) or on the ecology and impact those organisms have on the natural and agricultural environment (beneficial insects, harmful insects, and water and soil organisms).

The beginning of the second century of research, 1986–2011

In 1986, the Biosystematics Research Institute was renamed the Biosystematics Research Centre and assigned the mandate of accommodating the systematics needs of all the departmental research centres, as well as industry, government and academic laboratories, and the Food Production and Inspection Branch (now the Canadian Food Inspection Agency). Staff at that time included 48 systematists and seven retired emeritus scientists with broad expertise in insects, arachnids, nematodes, vascular plants and fungi. The Institute's activities in disciplines in which it had unique expertise extended beyond national borders, resulting in the identification of organisms through collaborative research and through the National Identification Service, which managed the assignment of internal and external requests to systematics experts.

The Reference Collections: National Treasures

- **Canadian National Collection of Insects, Arachnids and Nematodes**: This collection is one of the five largest invertebrate collections in the world in terms of species representation and level of curation. It contains approximately 16 million specimens from locations throughout Canada and North America, as well as from other biogeographic regions.
- **Vascular Plant Herbarium**: This is the largest collection of its kind in Canada. It contains approximately 1.5 million specimens that provide information for developing new crops and for ecological studies.
- **National Mycological Herbarium**: This collection was established in 1909 and contains more than 300,000 specimens. The herbarium provides critical information to the Canadian Food Inspection Agency, Environment Canada, Health Canada, as well as to private enterprise.
- **Canadian Collection of Fungal Cultures**: This is a collection of 11,000 living fungal cultures.
- **Glomeromycota *in vitro* Collection**: This is the only reference collection in the world of pure cultures of arbuscular mycorrhizal fungi.

Research on vascular plants, mycology and entomology was fed by extensive and ongoing fieldwork in strategic locations across Canada. These explorations made it possible to isolate, describe and identify the flora, fauna, and fungi that make up the country's wealth of biological natural resources. Preserved in five unique and irreplaceable reference collections, the specimens collected provide departmental researchers and those from other Canadian and foreign research institutions with a wealth of valuable information with which to address agricultural and environmental issues and conduct systematics studies of organisms or taxonomic groups targeted for their impact on environmental health.

Between 1986 and 1991, the Biosystematics Research Centre published some 30 major works, including books, manuals, illustrated guides, catalogues, atlases, and monographs as well as databases on insects, nectariferous plants, pollens, weeds, parasitic fungi, and tree parasites and saprophytes. In addition, dozens of descriptions of new insect, plant, and mycological species were published in international scientific journals and reviews, along with the classification of re-evaluated organisms into new genera or new families. The first microcomputers appeared at this time, facilitating a host of computer-based projects that produced, among others, inventories of wheat varieties, of the macroscopic fungi of Canada, and of plant and fungi associations. Over the years, as knowledge and technologies grew, these tools have been refined and collaboratively integrated into international biodiversity information systems (e.g. the Integrated Taxonomic Information System and the Global Biodiversity Information Facility).

In 1992, the Land Resource Research Centre and the Biosystematics Research Centre joined forces to become the Centre for Land and Biological Resources Research (CLBRR). The biosystematics mandate of the new organization focused on providing national leadership in crop protection, biological pest control and the development of biological indicators for a sustainable environment.

With the help of the computer, numerous widely accessible information systems were developed, notably on the poisonous plants of Canada, insects harmful to agriculture and plant diseases, and an international register of

Triticales and Canadian fungi. The publication of major works continued with the release of catalogues, manuals and monographs. The approach adopted by departmental systematists gradually shifted from the strictly taxonomic to one that focused on the functionality of organisms. Their work included a revision of decay-causing fungi, the treatment of arthropods as an indicator of soil quality, the role of arbuscular mycorrhizal fungi in plant protection and growth, the use of *Trichoderma* fungi to control soil parasites, herbicide-resistant weeds, and crop-destroying invasive plants.

In 1997, the biosystematics program became part of the Eastern Cereal and Oilseed Research Centre (ECORC), and the research was organized into two programs: invertebrate biodiversity/integrated pest management; and botany and mycology biodiversity.

Invertebrate biodiversity/integrated pest management research includes:

- Identifying and characterizing Canada's flora, fauna and mycota to define economically important fungi, insects, crops, and weeds;
- Studying ways to detect, measure and monitor changes in biodiversity in order to support the conservation and sustainable use of Canadian biological resources;
- Using molecular techniques to identify and determine the genetic diversity of insect pests, plant disease fungi, biological control agents, and weeds, and to identify economically important fungi;
- Developing knowledge on the classifications and relationships of important insect groups;
- Diagnosing and identifying tools to facilitate border protection against the introduction of exotic pests;
- Developing novel pest management strategies that exploit the natural enemies of pests and that can be integrated with current agricultural practices; and
- Discovering invasive species and helping control insect pests in an environmentally-friendly manner.

The advent of the Internet has allowed the wider distribution of information on the contents of the invertebrate collections. Several projects are underway to develop electronic databases related to the collections.

Research in the areas of botany and mycology biodiversity addresses four major issues: crop and weed molecular taxonomy, crop resources, fungal resources, and plant disease fungi. In recent years, the botany/mycology team has made significant discoveries and developed techniques, tests, and assays that have led to new inspection tools and contributed to the quality and safety of food.

Research highlights over the past 25 years

- Identified parasite responsible for *Phytophthora* root and stem rot in soybeans
- Discovered and identified fungi as vectors of diseases, particularly flame chlorosis, which attacks cereal crops
- Documented and evaluated the infectious potential of the molds found in urea formaldehyde foam (home insulation) that cause several allergic reactions in humans
- Introduced molecular systematics—by developing molecular primers to recognize nematode genotypes, and by studying the phylogenetic relationships between indigenous and cultivated plants of barley, canola/rapeseed, and alfalfa
- Developed molecular techniques that led to a significant increase in the ability to distinguish species—notably the DNA-based Barcode of Life project, which allows the identification of species even from tissue fragments
- Introduced the biological control agent *Diadromus pulchellus* to control the leek moth, which destroys garlic, leek, and onion crops in Ontario and Quebec
- Rapidly developed a molecular test for the detection of potato wart disease, enabling the lifting of a U.S. trade embargo

- Developed a new biological technique that allowed the identification of a new strain of late blight in potatoes and tomatoes, which had reached damage levels in Europe and North America in 2009
- Identified through taxonomic and chemical studies *Cannabis sativa* strains that produced very low levels of tetrahydrocannabinol (THC) for the hemp industry as well as Health Canada's medicinal marijuana program
- Maintained and managed the National Biological Collections of insects, plants, and fungi, which have helped resolve crises caused by organisms such as those responsible for potato wart disease and Asian soybean rust, and are key to identifying invasive weeds, which can save millions of dollars with the proper early control measures

The work of the Department's biosystematists has helped Canada with border security, biosafety, the protection of natural, energy and mineral resources, as well as environmental protection and conservation. Over the decades, biosystematists have increased biosystematics knowledge and enriched reference collections. Their findings are being used to classify living organisms, discover, describe and identify beneficial, invasive and parasitic species, and provide stakeholders with key concepts and knowledge for solving problems and developing effective biological tools. Because of its national collections, scientists from other branches and federal departments are located at ECORC, notably those from the Canadian Food Inspection Agency and the Canada Forest Service.

Animal Research
Ottawa, Ontario

James R. Chambers, Research Scientist, Research Branch, Guelph
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Animal research has been conducted at the Central Experimental Farm since 1889. The original mandate of this research was to promote agriculture through the dissemination of useful and practical information derived from research into the value of various breeds of livestock. This mandate has been modified over the years to better address the needs of the Canadian livestock sector and to exploit novel opportunities and niches as new scientific knowledge and innovative technologies developed. Research on dairy and beef cattle, sheep and poultry has contributed to increased scientific knowledge and the development of practices and tools that are in commercial use today. With the closure of the Centre for Food and Animal Research in 1997, components of the animal research program conducted in Ottawa were either phased out or transferred to other research establishments.

The early years, 1889–1985

Dairy and beef research in Ottawa began in 1889 with the acquisition of purebred registered bulls and cows of various breeds from Canadian and American herds. In 1890, a dairy barn was built to be used as a model for dairy farmers and to provide experimental evidence and data on milk and butter production. The early years of animal research in Ottawa also focused on cattle feeding and poultry raising, and later addressed cattle nutrition, reproduction and breeding, animal husbandry, bee management and honey production, and poultry breeding and nutrition.

The Animal Research Institute was created in 1959, with the formation of Research Branch. In 1970, the Dairy Technology Research Institute was amalgamated with the Animal Research Institute. The same year, the animals and some research activities were relocated from the Central Experimental Farm (CEF) to the 1,100-hectare Greenbelt Farm, located 14 kilometres from the CEF. This facility was also used to produce animal feed (forages and grain crops) and to dispose of animal waste. By 1980, the Animal Research Institute was renamed the Animal Research Centre.

In the 1980s, a major cattle breeding project was undertaken that involved breeding and selecting pure-line and cross-bred cattle and then evaluating the resulting effects on milk production, growth, feed efficiency and reproductive performance. In addition, the major poultry research program, established in the 1950s, was modified to emphasize breeding (egg production, eggshell quality, and disease resistance), the role of heredity on egg production, and genotype-environment interaction relative to mortality, feed conversion, and body weight. Another key animal research program was sheep breeding aimed at improving prolificacy, health, carcass quality, and growth performance.

In the mid-1980s, the Centre was the most important departmental player with respect to research on the breeding and genetics of dairy cattle, sheep, and poultry. In addition, it conducted programs on the nutrition and reproduction of these animal species, along with swine. Additional research, some using biotechnology methods, included studies of animal waste utilization, reproductive physiology, trace mineral and vitamin requirements, dietary utilization of fats and oils, animal behaviour and welfare, carcass evaluation, ruminant digestive physiology, and toxic contaminants in animal feeds.

The beginning of the second century of research, 1986–1997

In 1986, the Animal Research Centre, which had previously reported to Ontario Region, became part of the CEF administration. The Centre's mandate was to resolve the numerous problems associated with improving the production efficiency of intensively housed and managed livestock and poultry. The future direction of all research programs was evaluated in 1987, and biotechnology was emphasized to enhance research progress.

In 1989, the animal behaviour and welfare program was expanded and merged with the new environmental management program, led by researchers from the former Engineering and Statistical Research Centre. By 1990, dairy cattle breeding research and sheep production research were being completed. At that time, the new mandate of the Animal Research Centre was to conduct long-term research on the safety and quality of animal feeds and products, and on increased production efficiency, animal behaviour, and environmental management. Notable research involved mycotoxins and their role in the enhancement of feed and product safety.

Canadian Animal Germplasm

In 1992, a multi-partner national program led by CFAR that included research, documentation of genetic resources, cryopreservation and live animal conservancy was initiated to conserve Canada's animal genetic resources. The following year, the Canadian Animal Germplasm Technical Experts Board was established, and inventories of dwindling animal genetic resources were created.

In 1992, the Animal Research and the Food Research Centres were merged to create the Centre for Food and Animal Research (CFAR). The new organization had 300 employees, of which 78 were researchers and other research support professionals. The Centre's objective was to encourage projects that involved the staffs of both Centres and to foster industry participation. The principal mandate of the new Centre was to conduct long-term research on the safety and quality of animal feeds and products, and on biotechnology applications, to improve animal production efficiency, animal behaviour, and environmental management. Within each area of research, specific multidisciplinary research teams carried out studies on specific commodities, including dairy, beef, swine, and poultry, as well as projects in food safety, quality, and processing.

In 1994, animal research focused on technologies that could be commercialized or developed for the public good in several areas: food safety, biotechnologies that improved competitiveness of the animal sector, conservation of animal germplasm, improved animal behaviour and welfare, and environmental management.

In 1997, as a consequence of the 1994 Program Review, CFAR was closed. The animal research component was phased out, and the scientific expertise and equipment were transferred to and consolidated at other centres of excellence across Canada. The Greenbelt Research Farm located in southwestern Ottawa was transferred to the National Capital Commission.

Research highlights between 1986 and 1997

Dairy cattle

- Found that Vitamin E enhanced immunity and increased resistance to mastitis in lactating dairy cows
- Improved rumen efficiency by increasing the cow's protein utilization using various means, including amino acid-producing and bacteriocin-producing bacteria
- Improved the nutritional quality of milk—for example, decreased milk fat and improved fatty acid composition—through the use of bacteriocins, ionophores and modified diets
- Improved the efficiency of rumen bacteria, and identified, using molecular techniques, the genes in dairy cattle that confer mastitis resistance and desirable milk protein genes
- Revealed that crossbred dairy cattle mature earlier and have a longer, more productive herd life than purebred dairy cattle

- Developed procedures to transfer embryos and cell nuclei to surrogate host ova (without nuclei) in efforts to create numerous, genetically identical, elite progeny, and genetically identical live calves

Swine

- Demonstrated that formula for newborns containing canola oil (which contains less than 2 percent erucic acid) is safe for consumption by piglets and human infants
- Demonstrated that the growth rate and feed efficiency of hogs could be improved by replacing half of the dietary corn with naked oats plus supplemental lysine
- Improved farrowing crate designs and adapted them for commercial application to enhance welfare and productivity
- Developed a get-away pen system to confine piglets while allowing the lactating sows more exercise and access to a group lounge area
- Demonstrated that mycotoxins in moldy grains (corn, wheat) significantly decreased the growth rate and reproductive performance of swine
- Developed procedures and methods to quantify mycotoxin contamination of feed grains, to identify the types of damage done to animals that ingest contaminated feed, and to detoxify contaminated grains

Poultry

- Showed that the composting of chicken litter eliminated pathogens and odour, and yielded value-added fertilizer
- Identified endogenous viral genes in various chicken breeds (some of these genes reduced egg production) using biotechnology methods
- Showed that adding bacteriocin to liquid egg eliminated listeria

- Improved feed use and reduced fatness of broiler chickens by selecting for leanness and/or feed efficiency
- Showed that the genetic selection of hens for egg specific gravity was very effective in reducing egg shell breakage
- Adapted the True Metabolizable Energy technology developed earlier at the Centre to ensure more accurate biological evaluation of diet ingredients and the more efficient formulation of poultry rations
- Identified carriers of avian leucosis (a chronic infection that significantly reduced egg production), allowing removal of carriers and subsequent elimination of the infection

Sheep

- Developed three synthetic Arcott breeds—Canadian, Outaouais, and Rideau (recognized as new breeds under the *Livestock Pedigree Act* in 1988)—with greater potential for intensive lamb production than other breeds

Engineering and Statistical Research
Ottawa, Ontario

Neil McLaughlin, Research Scientist, Research Branch, Ottawa
Jean-Marc Deschênes, Director (1998-2001), Research Branch, Ottawa

Over the years, statistical research has provided high quality and much needed expertise and support to departmental scientific staff in the design of experiments, the development of statistical methodologies, and the analysis and interpretation of experimental data. In 1950, agricultural engineering research—including support and contribution to the Canada Plan Farm Building Service and the statistical services—was housed in the Administrative Division of Science Services in Ottawa. These units became the Engineering Research Service (ERS) and the Statistical Research Service (SRS) in 1958. The two services were amalgamated in 1977 into the Engineering and Statistical Research Institute, which was renamed the Engineering and Statistical Research Centre in 1986. The Centre was closed in 1989.

The early years, 1950–1985

Engineering research at the Central Experimental Farm, responsible for the design and fabrication of research equipment and apparatuses, dates back to the early years of research at the Department. With the creation of new research establishments and the expansion and increasing sophistication of research, it became imperative that new field plot equipment and laboratory approaches as well as mechanization and automation be available to cope with the increased volume of work and data.

In the early 1920s, drafting services for the construction of farm buildings were available at the Central Experimental Farm. In the mid-1940s, the Division of Field Husbandry, Soils and Agricultural Engineering began studies on farm building design. These activities represented an embryonic entity that together with agricultural engineering activities across the country, and design and drafting centres in Swift Current and Guelph, were the forerunners of the Canada Farm Building Plan Service, which was renamed the Canada Plan Service (CPS) in 1973. The Department's broad expertise in agricultural engineering research together with that of provincial departments and university faculties of agriculture contributed regularly over the years to the Canada Plan Service.

The use of statistics was introduced to experimental farms and science services in 1931. In 1945, a statistical unit was set up in the Horticulture Division of Experimental Farm Services, with the first statistician being appointed in 1950. The same year, agricultural engineering research, including support and contribution to the Canada Farm Building Plan Service and to statistical services, was set up in the Administrative Division of Science Services in Ottawa.

In 1958, agricultural engineering and statistical research were set up as two entities, namely Engineering Research Service (ERS) and Statistical Research Service (SRS). The main functions of ERS were to develop specialized mechanical and electronic research equipment for use by other departmental researchers, and to continue to support the Canada Farm Building Plan Service by developing building designs for farm structures including livestock housing, and crop and equipment storage facilities. The main function of SRS statisticians was to work closely with other scientists to carry out experimental design, data analysis and interpretation, and publication of the results in peer-reviewed scientific journals. The statisticians were also active in developing computer programs and statistical methods that were widely used throughout Research Branch for various types of statistical analysis.

In 1977, Engineering Research Service and Statistical Research Service were merged to create the Engineering and Statistical Research Institute (ESRI), which underwent reorganization and a large staff increase between 1978 and 1982 to support a contracting-out program on several subjects including energy, research on food processing, instrumentation and automation, and structures. The Institute continued to provide statistical services and support.

Between 1982 and 1985, the Institute's staff was reduced by 25 percent, and the Contracting-out Program ended in 1984, causing a shift to in-house research. Energy research and development was phased out, with some technology development continuing in-house, both in the Institute and other departmental research centres.

The beginning of the second century of research: 1986–1989

In 1986, the Engineering and Statistical Research Institute (ESRI) was renamed the Engineering and Statistical Research Centre (ESRC) and was reorganized into six sections: energy engineering, food process engineering, instrumentation and automation, structures and mechanization, statistical research, and technical services. There were 26 researchers including eight statisticians.

Energy engineering

ESRC had completely phased out energy research by 1987 and by the end of 1988 it finished all projects contracted out since 1973 under the three engineering programs. A comprehensive review of the resulting research was done, and more than 500 contract reports were summarized to evaluate the program, the potential for commercial adoption of the technology, and the state of agricultural energy research and development in Canada.

Food process engineering

Research in this area was undertaken in collaboration with industry to develop new methods for food processing. Many of the developments resulted in patent applications and subsequent licensing to industry.

Instrumentation and automation

This research focused on developing automated inspection and grading systems in collaboration with industry—to grade tomatoes, assess the colour of beef carcasses, inspect veal, and gauge the thickness of tobacco leaves. Assistance was provided to support departmental inspection of wheat carrier ships, electronic identification of livestock, and instrumentation development for crop environment assessment.

Structures and mechanization

Many of the research activities on farm structures supported the administrative and technical aspects of the Canada Plan Service. This research, done both in-house at ESRC and by contractors, included evaluation of conventional wind bracing systems and the structural stiffness of metal cladding and fasteners. The results of this research led to some redesign of existing farm building plans. Some of the older designs were re-engineered to conform to the newer version of the wood code for construction. *The Canadian Farm Buildings Handbook*, which provided recommendations for good practice, was published in English and French. It complements the structural requirements of the Canadian Farm Building Code and the National Building Code of Canada. Engineers and technologists worked with industry to mechanize fruit and vegetable field operations, as these are typically labour-intensive.

Working with NASA

The Engineering and Statistical Research Centre participated in the first NASA international field experiment program in Manhattan, Kansas, and developed the instrumentation to measure carbon dioxide (CO_2) and water vapour flux densities for assessing biomass growth and evapo-transpiration over large areas.

Statistical research

Statisticians continued to work closely with other scientists in animal, crop, and food science on experimental design, data analysis and interpretation, and scientific publications. The computer specialists maintained and updated a library of computer software that departmental researchers accessed approximately 1,000 times per month. The library included sample programs for various types of statistical analysis. Training sessions were provided on the operation of the software, and quarterly bulletins were prepared and distributed among Research Branch research centres.

Technical services

Staff provided support for research programs within the Centre by fabricating prototypes and specialized equipment. Trained technicians contributed to the design of the new equipment and performed the actual fabrication work. Technical Services also managed a separate group of maintenance personnel who provided maintenance services to other facilities at the CEF. This group was transferred to the Plant Research Centre in 1987.

Research highlights between 1986 and 1989

- Modified a tractor to utilize state-of-the art electronic instruments and a data-logging system to measure variables such as fuel consumption, implement-draft, and soil compaction forces in crop production systems using conventional and conservation tillage
- Developed a patented extrusion-microwave puffing process, which is in commercial use in the food processing industry
- Developed an electronic eggshell thickness gauge and computer interface for eggshell strength instrumentation
- Developed a patented continuous-flow food blanching system that is now manufactured by a Nova Scotia company and installed in many frozen food processing facilities

- Developed a tomato grader under contract that it is currently in use commercially
- Carried out research on ventilation that led to new designs and the wide use of naturally ventilated livestock barns in Canada
- Developed a prototype machine to tie the leaves over cauliflower heads, shading them from the sun to produce a white cauliflower, an operation that had previously been done manually
- Modified a mechanical cucumber harvester in collaboration with industry that reduced field loss and increased grower return by $250 per hectare for mechanically harvested cucumbers
- Showed that a mechanical strawberry harvester was economical and that the quality of machine-harvested strawberries was acceptable to the food processing industry
- Developed new analytical methods for designing and analyzing regional crop variety trials that on average increased precision by 10 percent
- Developed methods for designing taste panels for sensory evaluation of foods and analyzing the resulting data

In 1989, the Engineering and Statistical Research Centre was closed with some research projects on food processing engineering, instrumentation and automation, structures and mechanization, and statistical research being terminated, and some being transferred to other research establishments. The statisticians were originally transferred to Research Program Services (RPS) where they continued to provide wide-ranging support to projects and programs across Canada, by designing experiments, analyzing data, maintaining and enhancing computer software, and conducting research on statistical methodology. With the phasing-out of RPS in 1997, the statisticians were redeployed to various research centres.

Following the closure of the Engineering and Statistical Research Centre in 1989, the engineering machine and electronics shops were transferred to the Centre for Food and Animal Research (CFAR) and subsequently to the Eastern Cereal and Oilseed Research Centre in 1996.

Although the Engineering and Statistical Research Centre was no longer managing the Canada Plan Service, a network of agricultural engineers and livestock specialists continued to contribute and update the plans. The Canada Plan Service was still operating in 2011, with server space supplied by the Ontario Ministry of Agriculture, Food and Rural Affairs, but activity in producing new plans was much reduced. The service provides producers with existing plans for cost-effective animal housing and crop storage that include structural and environmental control technologies.

Chapter 5, Western Canada

Cereal Research Centre
Winnipeg, Manitoba

Brent McCallum, Noel White and Andy Tekauz, Research Scientists,
Research Branch, Winnipeg

The Rust Research Laboratory was established in Winnipeg in 1924 to develop cereal varieties for the region of the Prairies susceptible to rust diseases. It was renamed the Winnipeg Research Station in 1959 and became the Cereal Research Centre in 1995. The Centre is located on the campus of the University of Manitoba. Over the years, its mandate has expanded to incorporate other cereal diseases, cereal quality, biotechnology, and stored-products insects. The Cereal Research Centre played a central role in wheat cultivar development, having been involved in the discovery and deployment of rust resistance genes, Fusarium head blight resistance, the discovery, mapping and marker-assisted selection as well as the biological control of stored products insects, and the improvement of cereal quality.

The early years, 1924–1985

In order to combat the devastating problem of rust diseases, the Canadian government established the Rust Research Laboratory in Winnipeg in 1924. Its original mandate was to research rust diseases and to breed rust-resistant wheat and oat cultivars. Researchers made many landmark discoveries in rust biology, including the discovery of the sexual cycle in rust fungi, and conducted annual national virulence surveys to monitor rusts and other important diseases. Several rust-resistant cereal cultivars were released for use by farmers.

In 1956, a new building was erected opposite the original Rust Research Laboratory that became home to researchers from the Brandon Field Crop Insect Laboratory and from the Stored Product Insect Laboratory, whose staff had been working in downtown Winnipeg.

In 1959, with the creation of Research Branch, the complex was renamed the Winnipeg Research Station; in 1972, entomologists from the Parasite Laboratory in Belleville, Ontario became staff members.

Research on rust resistance combined with an emphasis on excellent end-use quality and superior agronomics resulted in the release by 1986 of 33 varieties of wheat, oat and barley cultivars. Among these were Neepawa (1969) and Katepwa (1981), which were the predominant wheat cultivars in Western Canada from 1972 to 1993. By 1986, wheat and oat cultivars developed at Winnipeg occupied 80 percent of the wheat-seeded areas in Western Canada, and 50 percent of the oat-seeded areas. The Winnipeg Research Station was a world leader in the discovery of resistance genes for species of rust in cereals.

The beginning of the second century of research, 1986–2011

In 1986, the Station's research focused on cereal breeding, cereal diseases, stored products and integrated pest control. The stored products and integrated pest control sections were combined in 1989 to form the Crop and Stored Product Pest Section. In 1992, a new chemistry and biotechnology section was formed, which evolved into the cereal biotechnology group, with expertise in fine gene mapping, cytogenetics, marker development, proteomics, molecular pathology and plant development. The Station had a multidisciplinary team able to focus on cereal cultivar development, on the chemistry of cereal grain quality, and on molecular markers linked to traits of interest. Integrated insect pest control research ended in 1995.

People and Programs: 1986

In 1986, there were 38 researchers working at the Winnipeg Research Station, in four sections:

- Cereal breeding: 12
- Cereal diseases: 10
- Stored products: 6
- Integrated pest control: 10

In 1993, the Winnipeg Research Station was renamed the Winnipeg Research Centre. To combat Fusarium head blight, which became an epidemic disease in Western Canada in 1993, research was initiated on the prevalence and the causal species of the disease, the epidemiology, and the mycotoxins, as well as on the development of genetic resistance in wheat, barley and oats. The Centre also established screening nurseries and protocols to be used by western Canadian cereal breeding programs to develop varieties that are resistant to the disease. Most of the screening for Fusarium head blight in wheat and oats is still done at the Centre. The Centre also initiated the Canadian Workshop on Fusarium Head Blight to focus research and share information in Canada on this important disease.

Cereal breeding and genetics have always been an integral part of work at the Centre. Efforts in wheat breeding were greatly enhanced by the establishment in 1993 of the Western Grains Research Foundation's check-off fund for wheat and barley. The Foundation has financially supported wheat breeding, allowing an expansion of activities while accelerating the development of elite new cultivars.

Technology for producing doubled haploid lines and populations of wheat was developed and optimized. Doubled haploid production, which is used extensively in research, became an important component of cultivar development. Recent wheat cultivar research by the Cereal Research Centre has had a major impact on wheat production in Canada, introducing many novel traits, including improved resistance to pre-harvest sprouting, leaf rust, and Fusarium head blight, and the development of resistance to the orange wheat-blossom midge. Some cultivars, such as Superb, which is derived from doubled haploid lines, set new benchmarks for high yield. The end-use quality of bread wheat has also been steadily improved or modified significantly to create different quality classes.

In 1995, the Winnipeg Research Centre was renamed the Cereal Research Centre (CRC) to reflect its mandate to conduct cereal research and cultivar development, particularly for wheat and oats, as well as to research barley pathology and quality (in collaboration with the Brandon Research Centre).

Genomic Research

The Cereal Biotechnology Section was deeply involved in the Department's genomics program, taking the lead in wheat genomics research in Canada. Genomics research targeted wheat leaf rust, cereal quality, Fusarium head blight resistance, genetic mapping, and molecular toolbox development for wheat (including extensive expressed-sequence tag (EST) work.) Researchers were also involved in the International Triticum Mapping Initiative, which had been established to map the wheat genome. The Section is also leading flax genomics in Canada, which involves whole genome sequencing, EST generation, genetic and physical mapping, and the development of molecular markers.

Major recent achievements in cereal biotechnology include: the development of markers for many important diseases, for insect-resistance, and for controlling quality traits, as well as cloning of the leaf rust resistance gene *Lr1*, and gene mapping of *Lr34/Yr18* that endows the resultant cultivar with durable resistance to many pathogens. In recent years, gene expression analysis has been investigated using microarray technology. Traits such as flowering, seed development and disease resistance were analyzed to determine the genes expressed during these critical developmental periods. This process has been taken one step further with research on the proteins produced or modified, leading to the ability to elicit important phenotypic changes in wheat. Proteomic research has focused on differentially expressed proteins that could be keys to disease resistance or other valuable traits.

The Prairie Oat Breeding Consortium

The Canadian Prairies have become the heart of oat production in North America, largely due to the use of cultivars developed at the Cereal Research Centre. The Prairie Oat Breeding Consortium (POBC) was created at the Centre in 1996. It is a joint federal-private sector oat breeding and development program. The consortium's mandate is to enhance commercial oat production in Canada, by developing disease-resistant oat cultivars that grow well on the Canadian prairies and have the processing and nutritional attributes that end users and consumers want. Since the Consortium's inception, the Department has released 11 oat cultivars, including two in Australia. In 2009, 75 percent of the oat acreage in Manitoba was seeded with varieties released by the Cereal Research Centre. This represents a proven return on investment in cultivar development through partnership with industry and the teamwork of the breeders, pathologists and food chemists.

To maintain the high quality and reputation of Canadian wheat, research has been conducted by the Cereal Quality Protection Section on the physical bread-making characteristics, chemistry and genetics of wheat grown in Canada. Research has focused on identifying the combinations of characteristics, particularly the glutenin and gliadin components, that impart superior bread-making qualities. Non-traditional uses for Canadian wheat, such as the production of Asian noodles and flat breads, have also been investigated. The wheat cultivars developed at the Centre have very strong gluten characteristics, which make them useful for blending with weak-gluten wheat produced by other countries. These extra-strong cultivars are also useful in the production of frozen dough products.

The potential uses of barley as food were also studied, with novel products such as barley tortillas and barley flour mixes being developed.

Cereal Research Centre leadership in the discovery and deployment of genetic resistance to rust fungi has accelerated since 1986, with the discovery and characterization of genes for wheat leaf rust resistance, wheat stem rust, oat crown rust, and oat stem rust. These resistance genes and those discovered previously at the Centre represent a major proportion of all known genes resistant to rust discovered worldwide to date. Many of these genes have been deployed in Canadian farm fields through the wheat and oat cultivars released by the Centre.

Research on stored products continues to be a high priority at the Centre. The stored-product entomologists of the Cereal Quality Protection Section maintain productive partnerships with the University of Manitoba; in 2004, a building was constructed on the campus specifically for conducting grain storage research, in order to strengthen this partnership.

Ug99

A large project has been initiated and is being led by the Cereal Research Centre to develop genetic resistance in Canadian cultivars to the wheat stem rust race *Ug99*, which is causing destruction of crops in Africa and the Middle East, and potentially threatens most of the wheat production areas of the world. Resistance to *Ug99* was identified in Canadian cultivars, including AC Cadillac and Peace.

In 2005, the Cereal Research Centre formed the Canadian Centre for Agri-Food Research in Health and Medicine (CCARM) in collaboration with the University of Manitoba and the St. Boniface Hospital Research Centre. CCARM is dedicated to understanding the health-related benefits of nutraceuticals, functional foods, and natural health products. As part of this initiative, the Department invested in the development of new labs and equipment and recruited two new researchers in 2008 and one in 2011, along with technical support, all to be located at CCARM. Research focuses on developing cellular and animal models in order to study the molecular basis of health benefits derived from Canadian agricultural and natural health products. It also concentrates on producing science-based evidence to substantiate health claims related to the effects on cardiovascular disease attributed to these products. Researchers at CCARM work closely with other departmental researchers across Canada.

Researchers at the Centre are also actively involved in collaborative research and mentoring more than 80 graduate students at the University of Manitoba since 1986.

People and Programs: 2011

There were 25 researchers working at the Cereal Research Centre in five areas:

- Cereal pathology: 6
- Cereal breeding: 6
- Cereal quality: 2
- Cereal biotechnology: 5
- Stored-products entomology: 3

The Centre also had three scientists working at the Canadian Centre for Agri-Food Research in Health and Medicine.

Research highlights over the past 25 years

- Discovered and characterized 44 genes for rust resistance—more than any other institution in the world over this period—establishing Canada as a world leader in the battle against cereal rust disease
- Released 51 cereal cultivars: 30 bread wheat, 4 durum wheat, 2 barley and 15 oat; these cultivars have a diversity of improved end-use quality characteristics, higher yields, improved agronomics, and enhanced resistance to pests

- Developed orange wheat blossom midge resistance, characterized the gene expressing this resistance (*Sm1*), and deployed it in Canadian wheat fields through high-yielding, excellent quality cultivars (i.e., Fieldstar VB, Goodeve VB, Unity VB and Glencross VB), saving Canadian farmers millions of dollars in direct losses and insecticide costs while enhancing environmental sustainability
- Developed the first semi-dwarf oat and the first crown-rust-resistant oat cultivar. The latter's success contributed to the Canadian prairies becoming the premier oat producer in North America
- Produced the Canadian Grain Storage CD-ROM (750 megabytes), which brought together a variety of information useful for the protection of stored products. The CD-ROM includes the Canstore expert system for grain storage management
- Developed on-site testing to help flourmills control pests without the need for annual methyl bromide fumigation
- Cloned the leaf rust resistance gene *Lr1*, only the third such gene to be cloned worldwide
- Developed a rapid DNA-based system to distinguish Canadian wheat cultivars, which was subsequently licensed to GeneServe Labs for commercialization
- Initiated a new wheat class, Hard White Spring Wheat, and registered the first two cultivars, Snowbird and Kanata
- Developed a consensus genetic map for wheat, and fine-mapped many important genes for marker development
- Surveyed annually all major diseases of cereals in Canada. Virulence analysis revealed important changes in these pathogen populations
- Registered two Fusarium-resistant wheat cultivars (Waskada and Cardale) that helped mitigate the impact of Fusarium head blight
- Released the cultivars AC Domain and Superb; these represented a major improvement in Canadian wheats for pre-harvest sprouting resistance and yield respectively

- Incorporated the resistance genes *Lr21* and *Lr22a*—both discovered at CRC—into cultivars AC Cora and AC Minto, saving producers from losses to leaf rust
- Developed and maintained extensive isolate collections for the major cereal pathogens for research and cultivar development purposes

The outstanding achievements in cereal science and cultivar development at the Cereal Research Centre since 1986 were only made possible through the multi-disciplinary team of pathologists, geneticists, entomologists, breeders, biotechnologists and cereal chemists.

The Centre plays a central role in wheat cultivar development in Canada as part of the Wheat Cultivar Development Cluster under the leadership of the Western Grains Research Foundation. It also plays a central role in oat cultivar development with the support of the Prairie Oat Breeding Consortium under the new Developing Innovative Agri-Products Initiative. The Cereal Research Centre is also leading the discovery and deployment of rust resistance genes in Canada and internationally, and the acceleration of wheat genomics, as well as the development of wheat cultivars resistant to Fusarium head blight. Effective biological control for stored products insects, and improvements in cereal quality, are also being pursued. The Centre is involved in genetic research to support the development of bioactive food components and to demonstrate their efficacy, and to integrate bioactives into the food system to improve human health. This research leads to the development of production systems that minimize environmental impact, maximize producer profits, and facilitate the maintenance of a safe and secure food supply that meets changing consumer requirements.

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Morden Research Station
Morden, Manitoba

Khalid Y. Rashid, Research Scientist, Research Branch, Morden

Founded in 1915 as an experimental farm, the Morden Research Station has made major contributions to the agriculture industry in Western Canada and across the country. Such contributions include the acquisition of knowledge and the development of technologies that have led to the production and release of several cultivars of flax, field peas, dry beans, buckwheat, potato, and sunflower hybrids with high yield and quality, and disease resistance. Products of the landscape ornamental research program have beautified public spaces and private gardens with aesthetic plants that have been widely adopted by the Canadian public. The new laboratory and office building built in 1989, and the well-equipped level-3 quarantined plant pathogen containment facility, have contributed to the success of the Station's research program. The Station continues to work with all stakeholders in the flax and dry bean industry to develop tools and practices to produce and release new superior cultivars adapted to Manitoba, the Prairies and to Canada as a whole.

The early years, 1915–1985

Originally created in 1915 as an Experimental Station, the Morden Research Station—as it was renamed in 1966—had a wide research mandate that encompassed animal production, field and vegetable crops, fruit trees, shrubs and shade trees. The focus of the research was on the breeding and management of field and horticultural crops, small fruit trees, landscape trees and shrubs, and woody ornamentals. The Station also had a mandate to manage the research field site in Portage la Prairie.

Research in animal production was carried out on Ayrshire dairy cattle, Percheron horses, Hampshire sheep, Barred Rock and Rhode Island Red poultry, and honey bees. The work concentrated on breeding to improve genetics and on feed quality to improve the rations for higher performance and productivity. Animal research was terminated in 1960.

Research into breeding, agronomy and disease resistance for various field and horticultural crops resulted in the release of many adapted and improved cultivars of oilseed flax, field peas, buckwheat, potato, tomato, cucumber, horseradish, garlic, Jerusalem artichoke, sweet corn, corn, and sunflower inbred lines and hybrids that occupied a large area of production in Western Canada. Cold-tolerant cultivars of apple, crab apple, pear, plum, cherry, apricot, almond, raspberry, and sandberry were also released and were widely adapted to the cold climate of the Prairies. Several landscape trees and shrubs, such as poplar, ash, and lilac, were also bred and released to the general public and were successfully adapted to Western Canada. Dozens of widely adopted cultivars of rose, lily, monarda, and chrysanthemum were also bred and released. The Station maintained germplasm of herbaceous and winter hardy ornamentals, small-fruit trees such as apple and pear, shade trees, special and alternate crops including flax, sunflower, corn, buckwheat, and field pea, as part of the National Genetic Resource Conservation program.

By 1985, the field crops section at Morden was carrying out research related to breeding field pea, corn, buckwheat and lathyrus, as well as research on pulse crop pathology, weed sciences, and crop physiology and management. The horticultural crops section focused on the breeding of woody ornamentals, research on food science and technology, and the management and storage of potato. The oilseed crops section's work included breeding, pathology and agronomy research on flax and sunflower.

The beginning of the second century of research, 1986–2011

Because the corn growing area in Manitoba began to expand west towards Brandon and southwest Manitoba, especially with the introduction of early maturing hybrids, the corn breeding program was moved to the Brandon Research Station in 1986 to facilitate the breeding and selection of adapted breeding lines for the western part of the province.

People and Programs: 1986

The Morden Research Station had a total of 59 employees, including 19 researchers working in three sections:

- Field crops: 7
- Horticultural crops: 8
- Oilseed crops: 4

In 1989, a new office and laboratory building was built at the Station to replace some of the small old buildings, and to make it possible to house all the scientific programs under one roof. The new building contained food research laboratories, a phytotron, and a modern seed storage facility for short and long term seed storage of germplasm. The new building included a level-3 quarantined plant pathogen containment facility, the only one in Western Canada at that time, for research on flax rust, a major disease affecting flax that was drastically reducing crop yield. This facility was used in research studies to identify resistance to the potentially dangerous new exotic races of wheat stem rust (*Ug99*). Employees from the Agri-Environment Services Branch and the Canadian Food Inspection Agency were re-located from offices in the town of Morden to the new building.

In 1994, the Station was designated as the Agri-Food Diversification Research Centre, with a mandate to develop improved cultivars and better production and protection practices for flax, field pea, sunflower, buckwheat, potato, and alternative crops, to undertake quality research to enhance the marketability of these crops, to develop landscape plants for the Prairies, and to maintain germplasm of the alternative crops and winter-hardy woody ornamentals.

Station's 75th Anniversary

In the summer of 1990, the Morden Research Station celebrated its 75th anniversary by organizing tours of the field research plots and the new laboratory research facilities. The Station also hosted the regional farming community, national scientific collaborators, national trades and value-added enterprises for discussions of the scientific programs and their impact on the agricultural industry in Canada.

In 1995, research activities in Research Branch were consolidated, and the sunflower breeding, buckwheat and lathyrus breeding, potato management, weed science, horticultural crops, and food science and technology programs were phased-out at Morden.

By 1996, the Centre had returned to being known as the Morden Research Station and was linked to the Cereal Research Centre in Winnipeg. At that time, the Station had six researchers and a number of support staff, and had a mandate to develop cultivars of flax, field pea and woody ornamentals with improved performance and disease resistance. During this period, the Station also hosted additional programs, such as United Grain Growers' low-linolenic-acid Solin flax breeding program, and carried out collaborative work with the Agassiz Irrigation Association and the Kade Research program (buckwheat).

In 2004, the field pea breeding program was re-located to Lacombe, Alberta, while the dry bean breeding program was strengthened by the appointment of a dry bean breeder. By 2009, the ornamental program ended, and all non-government programs were discontinued at the Station.

The Station manages 254 hectares of land for short- and long-term research. An arboretum of 26 hectares contains more than 3,500 woody ornamentals and fruit species and cultivars. The northwest corner of the Station is a maintained landscaped area—with displays of various shrubs, trees and cultivars—that has been widely used by the local residents as a small park and picnic grounds.

People and Programs: 2011

The Station had 35 employees including four researchers working in two sections:

- Flax: 2
- Beans: 2

Research highlights over the past 25 years

Flax

- Released more than 20 multigenic resistant cultivars (rust, Fusarium wilt, and powdery mildew) between 1985 and 2010

Sunflower

- Released 10 disease-resistant hybrids adapted to conditions in Manitoba and Saskatchewan
- Identified genetic resistance in wild perennial sunflower species from Manitoba
- Identified new races of rust, downy mildew, Verticillium wilt, Sclerotinia wilt and head rot

Field pea

- Focused on breeding green- and yellow-seeded cultivars for high yield, high protein, high fibre, and genetic resistance to major diseases
- Released cultivars with resistance to root rot, ascochyta blight and powdery mildew

Dry bean

- Developed and released several cultivars in the pinto, black, small red, and navy bean classes with high yield, good seed quality and disease resistance

Buckwheat

- Released high-yield, cold-hardy, and frost-tolerant buckwheat cultivars
- Developed self-pollinating and dwarf buckwheat genotypes

Potato

- Evaluated and selected cultivars adapted to the growing conditions in Manitoba
- Released several table- and chip-potato cultivars with improved yield, quality and resistance to Verticillium wilt and early blight

Landscape plants

- Developed new and improved cultivars of trees, shrubs and herbaceous perennials widely adapted to Western Canada
- Developed and released a series of cold-hardy roses (the Parkland Rose series)
- Released cultivars of poplar, ash, lily, monarda, chrysanthemum, and penstemon for the Canadian market

Food research

- Extracted the peroxidase enzyme from horseradish for use in the medical field
- Identified geranoil-rich monarda for industrial purposes
- Studied and developed storage conditions for high frying quality in chipping potato

- Developed a biodegradable film from pea starch and protein for food wrapping
- Developed a methodology for isolating and characterizing anthocyanins and flavonoids from plant sources for the food industry

Weed science

- Identified major weeds impacting flax, buckwheat, field pea, sunflower, and potato
- Collaborated with industry to identify compounds with high efficacy and specificity in controlling weeds in special crops

Alternative crops

- Released germplasm of spices, oilseeds, crops, and other plants for flavouring and cosmetics, and plants with special sugars and proteins for human food, animal feed, and pharmaceuticals
- Researched and released cultivars of dill, soybean, favabean, mungbean, lentil, chickpea, Jerusalem artichoke, horseradish, lathyrus, coriander, and fenugreek

By 2011, research at Morden was being carried out by four researchers with a mandate to develop and release superior oilseed flax and dry bean cultivars of various types. The criteria being sought are improved performance adaptability and genetic disease resistance for the Canadian Prairies, as well as quality traits for meeting industry and customer demands in Canadian and international markets. The Morden Research Station works with all stakeholders in the flax and dry bean industry to develop tools and practices to produce and release new superior cultivars adaptable to Manitoba, the Prairies and the country as a whole.

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Brandon Research Centre
Brandon, Manitoba

Wayne T. Buckley, Mario C. Therrien and Katherine E. Buckley,
Research Scientists, Research Branch, Brandon

The Brandon Research Centre is one of the five original agricultural research facilities established by the federal government in 1886. It was created as the Brandon Experimental Farm, renamed the Brandon Research Station in 1959 and the Brandon Research Centre in 1993. Early research resulted in the breeding and distribution of crops and livestock suitable for the harsh climate of the eastern prairies. Management systems were developed and tested for controlling weeds and improving soil quality and crop yield. Today, the Centre is building on past research: to develop integrated livestock and cropping systems; breed malt and feed barley for better disease resistance, malting quality and yield; mitigate disease incidence and severity in high value food crops; and enhance knowledge of seed, plant and soil response to environmental and nutritional factors with the goal of improving economic and environmental sustainability in the Parkland ecoregion of Western Canada.

The early years, 1886–1985

The Brandon Research Centre is one of the five original agricultural research facilities established by the federal government in 1886. It was then known as the Brandon Experimental Farm. The original land, located along the Assiniboine River, includes valley bottom land as well as tableland, and is still occupied by the Centre today.

Technologies developed elsewhere were tested at the Centre for suitability to the prairie environment. Seed of superior crop varieties and stock of superior animal breeds were distributed to farmers. During the first 10 years after establishment, 40 varieties of spring wheat were evaluated for improved rust resistance and early maturity. Large numbers of trees for shelterbelts were grown for distribution to farmers. A cattle program was initiated with the introduction of purebreds. Methods of utilizing home-grown crops for feed to improve farm income by overwintering cattle were investigated beginning in 1892. Before the turn of the century, testing was initiated to select hardy fruit trees and bushes adapted to the harsh climate.

During the years of drought beginning in 1920, experiments were carried out to evaluate new soil conservation methods to minimize soil and moisture loss. A six-row barley breeding program was begun in 1923, spearheading the effort to breed high yield malt and feed cultivars with resistance to disease. The introduction of Italian bees and the study of the life cycle of 21 prairie species of grasshopper were the focus of the early innovative work at the Centre. The swine program, initiated in 1891, was expanded after the First World War when the use of alternative feed ingredients and feeding methods was investigated. The feeding program later evolved into a swine breeding program.

In the 1940s, more detailed studies were undertaken on the effects of various cultural practices on the yield response of wheat and barley grown in the diverse soils of the eastern Prairies. Experimentation with varying amounts of crop nutrients was conducted to improve crop yield. The study of husbandry practices for sheep, poultry, and horses, and the identification of suitable horticultural crops rounded out the Farm's early activities.

In 1959, with the creation of Research Branch, the Farm was renamed the Brandon Research Station. As agricultural production became more specialized, the focus of activities at the Station shifted from testing and demonstrating to research and development. At the same time, a number of livestock, insect and horticulture programs ended, while an increasing emphasis was placed on beef, swine, barley, corn, forage crop production, soil management and weed control.

A large-scale cooperative program was developed in Brandon and Lacombe to evaluate Limousin-, Simmental- and Charolais-sired top crosses out of Herford, Angus and Shorthorn cows. Swine management, breeding, and reproductive physiology programs were initiated to improve meat quality and increase the number of weaned piglets. Barley breeding efforts continued to combat stem diseases and improve malt and feed yield and quality. Before 1986, more than 50 percent of all barley varieties grown in western Canada and over 80 percent grown on the eastern prairies were developed at Brandon. Numerous agronomic experiments conducted at Brandon from 1970 onwards, in collaboration with the University of Manitoba and the Manitoba Corn Growers' Association, resulted in an increase in the production of grain corn. During this period, greater effort was directed toward improving forage production through fertilizer management, crop management, and species selection. From 1970 to 1986, soils research was refocused to determine the effect of geographical location, fertilizer form, and fertilizer placement on nutrient-use efficiency and crop yield, both for traditional crops and for new introductions such as soybean and flax. Weed research was expanded to other field crops besides cereals and rapeseed. New cultural and chemical control methods were introduced for wild oats and other weeds in sorghum, flax, forages, potatoes, beans and lupines.

The beginning of the second century of research, 1986–2011

In 1986, the facilities at the Brandon Research Station included a main office complex, a secondary laboratory and office building, a field laboratory building, a working beef cattle ranch, several swine research buildings, housing for livestock staff, a machine shop, and a number of other storage and minor-use buildings. The Station also leased from the province a section of land, east of Brandon, to provide for extra pasture and livestock feed. There were 14 researchers at the Station.

Research activities were divided into two main programs: animal science, and plant and soil science. The animal science group included seven scientists working in the areas of beef cattle genetics and production, swine genetics, swine physiology and production, and meats physiology (beef and swine). From 1986 to 1989, beef research focused on genetics and breeding. Genetics research was devoted to helping beef cattle producers choose breed crosses that would maximize productivity under range and pasture conditions, and to identifying hybrids with superior meat quality. In 1989, research was begun on best management practices for raising beef cattle on pasture. Studies on reproductive physiology, initiated in 1994, included the evaluation of hybrid cows for reduced calving difficulty, and the synchronization of ovulation to improve calving efficiency.

Swine research was aimed at improving swine genetics and production efficiency. Genetics research focused on the growth and body composition of pigs in order to select for lower back fat while maintaining a lean meat product acceptable to consumers. Research was conducted into the nutrition and physiology of reproductive performance as well as factors affecting the onset of puberty. Nutritional research included many studies on developing swine rations that utilized various protein supplements, including lentils, soybean and peas. Mineral nutrition was emphasized, along with the development of optimum grower, finisher and gestation diets. Meat quality studies and meat-processing techniques were integrated with growth, body composition and nutritional studies. Methods of reducing “boar taint”—an unpleasant flavour and odour in some pork—were investigated, as were improvements in litter size and piglet survival.

The plant and soil science program included seven researchers focusing on agronomy, plant nutrition, soil fertility, weed control, forage and barley breeding. Advances were made: in the use of soybean inoculants for early maturing soybean varieties; in phosphorous, calcium and zinc requirements and optimum phosphorous placement for flax and cereals; in nitrogen responses of spring wheat and other cereals; in potassium and chloride nutrition of barley; on the impact of soil conditions on fertility; and in the use of herbicides and adjuvants for the control of wild oats, green foxtail, and other weeds. The barley breeding program was expanded to include two- as well as six-row malting barley. Work on forage and feed barley for the Canadian prairies continued while, in 1987, the development of disease resistance in malting barley became a major part of the breeding program. Corn breeding research, which had begun in 1976, was re-instated after a hiatus of several years in an effort to develop early-season inbred corn lines that could be used for the production of hybrids by the industry. Between 1986 and 1995, 11 early-season inbred lines were released.

A New Office and Laboratory Complex

In 1992, a new office and laboratory complex was built just north of the existing office complex. The new building, along with replacement of and renovations to other aging buildings, provided the researchers with modern facilities. The old office complex was demolished and the site marked with a cairn.

In 1993, research in biochemistry and plant physiology was added to the Plant Science program. The Brandon Research Station was renamed the Brandon Research Centre in 1993, and its primary mandate became research for the Black soils zone (also called the Parkland) of the Canadian Prairies, a major agricultural ecoregion. Several changes occurred with the consolidation efforts of Research Branch in 1995. The soils and crops research in Brandon was expanded to include other disciplines, such as biochemistry, economics, micrometeorology, plant pathology and soil microbiology, with an emphasis on land management. The management of the Department's Land Resource Unit for Manitoba was added to the Centre.

Swine research was phased out over a three-year period ending in 1997, largely being taken over by the Dairy and Swine Research and Development Centre in Sherbrooke, the University of Manitoba, as well as by private industry. Although the breeding and reproductive physiology research in beef ended, the research in other aspects of beef production continued. The corn breeding program was discontinued when the industry assumed leadership of the cold-season inbred program.

By 1998-1999, the Centre employed 25 professionals, the largest number in its history. Research at Brandon included integrated agricultural management, barley breeding, beef production systems, soils and cereal agronomy, crop micrometeorology, crop pathology, economics, manure management, plant pathology, plant biochemistry and physiology, soil conservation and microbiology, weed crop ecology and weed management.

In 1998, a one-half section farm (Philips Farm) north of Justice, Manitoba, was purchased to expand the area for land-based research. The following year, a large-scale demonstration and research composting site, covering two hectares, was set up for feedlot manure.

Barley Breeding Program

In 1997, the barley breeding program released AC Metcalf, which has become the most widely grown malting barley variety in North America. An objective of current barley breeding is to develop resistance to Fusarium head blight, a major disease of grain crops in Western Canada.

By 2004, research in beef production systems emphasized cost-effective production of high-quality beef through production and nutrition management. As well, pasture management research and studies on methane (a greenhouse gas) production by cattle had been included. Research in land resource management included agronomy, plant nutrition, soil fertility and microbiology, biochemistry, micrometeorology, physiology and weed science. Barley breeding continued to focus on the development of new varieties with desirable disease resistance and quality characteristics.

Research at Brandon contributed to the increased use of conservation tillage systems, by investigating the effects of reduced tillage and intensified cropping on weed dynamics, nutrient relations, crop pathology, soil conservation, water utilization, and production economics. Studies were conducted on: the effects of reduced tillage on crop responses to major nutrients; the physical properties of soil as well as the organic carbon and nitrogen in soil; improving the efficiency of fertilizer practices, including seed-placed and side-banded nitrogen; new management and fertility practices for oats; the effect of tillage and cropping systems on weed dynamics; reducing herbicide inputs; and, integrated approaches to disease management for the production of canola, potato, and pulse crops.

Work at Brandon has provided information on the impact of nutrient and manure management practices and tillage systems on greenhouse gas emissions, ammonia volatilization, and the accumulation of nitrate, phosphorus, and other nutrients in the soil. Knowledge gained on the recycling of nutrients in integrated farming systems is helping to reduce the risk of nutrient transfer to the air and water. The economic cost of recommended practices has been assessed against the benefit to the environment.

Researchers in land resource management also have been involved in the development and evaluation of advanced agricultural technologies. Studies examined the use of satellite imagery to evaluate crop leaf nitrogen, the pushing of canola (physically bending the plants down) as an alternative to swathing, the development of new methods to measure seed vigour of canola and seed storage capacity of barley, and the adaptation of alternative crops for the Prairies.

Conservation Tillage Systems

In the past 25 years, the Brandon Research Centre has contributed to the widespread adoption of conservation tillage on the Prairies. Conservation tillage systems are a means of conserving soil moisture, reducing soil erosion and decreasing input costs. The need for moisture conservation has encouraged more intensive and diversified cropping systems and has allowed growers to take full advantage of growing-season precipitation on the Prairies.

Food safety, specifically the accumulation of cadmium (a toxic heavy metal) in crops, has been studied at Brandon. Work has addressed the physiology of cadmium uptake by plants and evaluated the effects of tillage systems, crop rotations, manure and compost applications, as well as fertilizer management on its accumulation.

Research highlights over the past 25 years

Swine

- Improved growth and body composition, including leanness and back-fat thickness
- Improved grower/finisher diets, particularly protein supplements

Beef

- Evaluated cow productivity, carcass traits, post-weaning growth, feed efficiency and the economics of beef breed crosses
- Advanced the understanding of the physiology of luteal (progesterone-producing) cells in beef
- Contributed to the understanding of ovulation synchronization and fertility in cattle
- Advanced grazing management methods of alfalfa-grass pastures
- Advanced the development of extended-season grazing systems, which reduced the cost of feeding cattle in winter

Agronomy and environment

- Developed herbicide and adjuvant recommendations for weed control on many crops
- Developed production practices for optimizing flax fibre production
- Formulated many recommendations for fertilizer management in tillage systems—including zero- and minimum tillage—for grains and oilseeds
- Improved crop nutrient balance through the use of composted manure
- Mitigated the environmental impact of manure application through solid/liquid separation treatments

- Developed fertility and management practices for oat production
- Evaluated soil carbon and structure in crop rotations and tillage systems

Agricultural economics

- Studied the economics of alfalfa, flax, potato, and pea-wheat management systems

Biochemistry

- Developed new techniques for seed-quality assessment

Barley breeding

- Released 14 new barley varieties, many of them with unique and important characteristics
- Released forage barley varieties AC Virden (1986) and AC Ranger (2001); the latter became the most widely grown non-malting barley in Canada
- Released the two-row barley variety AC Metcalfe (1997), the most widely grown malting barley variety in North America
- Released 11 other barley cultivars
- Developed molecular marker and doubled-haploid technologies

Corn breeding

- Released 11 early-season inbred lines

The Brandon Research Centre uses a "systems approach," looking at the interactive effects of tillage system, nutrient management, crop genetics, crop sequencing and animal waste management on a range of important factors, including crop yield, crop quality, weed ecology, micrometeorology, crop diseases and economics. The Centre's research activities are building a strong focus on the integration of crop and livestock production systems to improve agricultural production, economic sustainability and environmental sustainability in the highly productive Parkland (Black soil) ecoregion of Western Canada.

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Saskatoon Research Centre
Saskatoon, Saskatchewan

Owen Olfert and Karen Bailey, Research Scientists, Research Branch, Saskatoon

From its beginnings in 1917 as an entomological laboratory, the Saskatoon research facility was well placed to make significant scientific advancements in the development and management of crop commodities grown on the Prairies. Researchers focused on improving oilseed germplasm, developing hardy disease-resistant forage crops and bloat-free alfalfa, and reducing the impact of weeds, insects and plant diseases on crop production. The Saskatoon Research Centre is continuing its research effort to quantify the risks and benefits associated with implementing mitigation strategies using ecologically sound integrated management approaches. As well, it continues to investigate the use of traditional agronomy and breeding strategies, coupled with modern biotechnology tools and approaches, to increase crop yield potential, improve quality, and enhance sustainability. Further development of new bioproducts bio-pesticides, bio-industrial chemicals, bioactive compounds and bio-based materials from crop feedstocks and their applications continues the diversification of agricultural products, opens new market opportunities and stimulates agri-business activities.

The early years, 1917–1985

Experimental work began in Saskatoon in 1917 with the establishment of the Entomological Laboratory, then the Laboratory of Plant Pathology in 1919, and then the Forage Crops Laboratory in 1931. These laboratories, housed on the campus of the University of Saskatchewan, were created to tackle problems with biting flies, grasshoppers, wireworms, rust, common root rot, loose smut, bacterial wilt, to investigate forage husbandry and cultivar development, and to support the emerging oilseed industry.

A reorganization of the Department of Agriculture in 1937 planted the seeds of an idea for a new Science Services building on campus, and after several delays, its construction and its occupation by staff took place in 1957. The completed building had 60 offices, 30 laboratories, 16 utility rooms and five greenhouses. It became known as the Saskatoon Research Station in 1959.

Although field research was a necessary component of the research program, the station had limited facilities on campus and had to share land with other organizations or use field sites outside the city. In 1964, when the Prairie Farm Rehabilitation Administration closed its doors, it sold its 162 hectares of land in Sutherland to the City of Saskatoon for one dollar, leading to the establishment of a park and horticultural area for the city, along with 73 hectares of field land for the Station. Various buildings were constructed in the 1960s, and more land (approximately 32 hectares) was added to the site in the 1970s.

Since its establishment, the combination of core research in oilseeds, forages, and plant protection, and the consolidation of facilities, created the conditions whereby the Station became an important player in the agricultural research community.

In the 1970s, in collaboration with the University of Manitoba, the Station contributed to the development of "canola", a modified rapeseed (from which erucic acid and glucosinolates have been removed) that is safe for human and animal consumption.

By 1985, the Saskatoon Research Station was a hub of agricultural research activity in Western Canada. Breeding, agronomy and the management of plant diseases and insect pests were key research areas. Saskatoon played a major role in research on rapeseed-canola and mustard, and on the development of forage grasses and legumes for the northern Prairies. To accommodate increased fieldwork, an additional 50 hectares were added to the existing land base.

The beginning of the second century of research, 1986–2011

In the mid-1980s, the Saskatoon Research Station focused on improving oilseeds (rapeseed, canola and mustard) management, yield, and insect pest control, on developing forage grasses and legumes for the northern Prairies, and on developing bloat-safe alfalfa. Pathology research focused on controlling root rot of wheat and barley, sclerotinia stem rot, white rust and blackleg on canola and other oilseeds, and crown rot of alfalfa. Entomology research concentrated on flea beetle and bertha armyworm on canola, false chinch bug and moths on sunflower, sweet clover weevil and *Lygus* bugs on forages, grasshoppers on cereals, and black flies in the waterways.

People and Programs: 1986

The Saskatoon Research Station had 34 researchers working on:

- Oilseed breeding: 12
- Cereals: 5
- Forage crops: 8
- Insect pest management: 9

Research efforts remained stable over the next few years, with only minor changes to programs and facilities. Over time, teams formed to specialize in the development of insect and disease control systems for oilseeds, cereals, and forage crops. All of the programs acquired stronger research support from researchers in plant biotechnology and chemistry and through collaborations on the processing of grains and oilseeds with the POS Pilot Plant Corporation in Saskatoon.

In 1992, additional research units were added, expanding scientific expertise for conducting weed surveys, and for cereal and oilseed processing and chemistry. In 1993, the Station was renamed the Saskatoon Research Centre and was made responsible for management of the Melfort Research Farm. The closure of the Regina Research Station program in 1995 resulted in the relocation of researchers and other employees to Saskatoon.

In 1995, the programs were consolidated and the facilities rejuvenated. The laboratory facility underwent a major upgrade, while the farm site acquired a new field services lab and increased its land base to a total of 242 hectares. There were also new greenhouses, laboratories and controlled-environment chambers—specialized labs for fermentation, spray application, DNA sequencing and the containment of regulated and exotic plant pests.

Research Partners

Canadian universities:
Alberta, Brandon, Guelph, Laval, Lethbridge, Manitoba, McGill, Nova Scotia Agricultural College, Saskatchewan, Simon Fraser

Provincial and federal organizations:
Alberta Agriculture Food and Rural Development, Alberta Research Council, Environment Canada, Genome Canada, Genome Atlantic, Genome Prairie, Health Canada (Pesticide Management Regulatory Agency), Canada Food Inspection Agency, Manitoba Agriculture, National Research Council (Plant Biotechnology Institute), Natural Resources Canada (Canadian Forestry Service), Natural Sciences and Engineering Research Council, POS Pilot Plant Corp., Saskatchewan Ministry of Agriculture, Saskatchewan Research Council

International collaborators:
Consortium of Consultative Group on International Agricultural Research (CGIAR) centres worldwide, Brazil (EMBRAPA), Europe (CABI, INRA), New Zealand (Ag Research, Land Care), U.S. (USDA-ARS, U.S. National Renewable Energy Labs)

Renovations also included the transfer in 1998 of the Plant Gene Resources of Canada to Saskatoon from Ottawa, where it had been located since 1970. This gene bank is associated with the worldwide network of plant gene banks established in collaboration with Bioversity International (International Plant Genetic Resources Institute) and the United Nations Food and Agriculture Organization. The gene bank was a good fit with the Centre's mandate to conserve, characterize and distribute diverse crop germplasm, and presently has more than 550,000 seeds. Its relocation to Saskatoon also allowed a research component in genetic diversity studies to be added to the services offered by the seed gene bank.

Along with the renovations, the research mandate was modernized as well, to support a long-term commitment to crops research for the agri-food industry in Western Canada, delivering improved germplasm of oilseed and forage crops, developing crop production- and pest control practices for the Parkland region of Saskatchewan, and conducting research to expand the utilization of prairie crops. These changes to program direction included:

- Refocusing oilseeds breeding to concentrate on *Brassica rapa*, *Brassica napus*, *Brassica juncea*, *Brassica carinata*, and *Sinapis alba*;
- Creating a new molecular genetics section in 1997 to provide biotechnology support to the oilseeds breeding programs;
- Restructuring forage research on range and pasture management, diseases, and forage and grass breeding;
- Integrating weed management and crop protection into ecological crop protection, with the inclusion of programs on insect and weed ecology and biological control, integrated pest management, herbicide resistance, and weed surveys; and
- Enhancing crop utilization by specializing in crop fractionation and the natural-product chemistry of flavonoids, sterols, terpenes, phenolics, alkaloids, starch chemistry, and chemical synthesis.

By the turn of the millennium, the Saskatoon Research Centre had grown to approximately 174 employees including 44 researchers with scientific expertise in plant breeding, plant pest management, biotechnology and genomics, and natural-product chemistry. Its mandate focused on integrated crop production systems, the genetic improvement of oilseed, forage, and legume crops, genetic resources conservation, and bioproducts and bioresources.

Under the integrated crop production systems program, the research team developed knowledge, tools and practices that allowed the sector to quantify the risks and benefits associated with implementing mitigation strategies, using an integrated management approach (chemical, biological, cultural, bio-pesticides, cultivar resistance, agronomy) while remaining ecologically sound.

The program for the genetic improvement of oilseed, forage and legume crops used traditional breeding strategies coupled with modern tools and approaches to genetic improvement to increase crop yield potential and sustainability, and improve quality. The benefits to prairie agriculture included the production of oilseeds, forage, and legume crop varieties that had high yield potentials, desirable quality profiles, and tolerance to biotic (diseases and insects) and abiotic (heat, cold, drought, and nutrient availability) stresses.

The genetic resources conservation research team focused on ensuring the availability of genetically diverse plant and farm-animal bioresources. It also focused on conserving the genetic material required in order to select for and improve productivity and quality, on resistance to pests and diseases, on adaptability to changing and adverse growing conditions, and on developing bio-based products. This research met Canada's international commitments under the Convention on Biological Diversity and the International Treaty on Plant Genetic Resources for Food and Agriculture.

Working with Industry and Commodity Groups

The Saskatoon Research Centre has a longstanding tradition of working collaboratively with individual companies as well as related industry associations and grower commodity groups, including:

Bayer Crop Science
BC Grain Producers Association
Bioconversions Network
Biopesticide Industry Alliance
Camelina Association
Canola Council of Canada
Cellulosic Biofuels Network
Crop Life Canada
Flax Canada 2015 Inc.
Ontario Hemp Alliance
Pulse Canada
Rare Breeds Canada
Saskatchewan Forage Council
Saskatchewan Mustard Development Commission
Seeds of Diversity Canada
Sem BioSys Genetics
Triticale Biorefinery Initiative
U.S. Complex Carbohydrate Center
Viterra Inc.

In December 2004, the Canadian Animal Genetics Resources Program was created as a joint initiative of the Centre, the University of Saskatchewan's College of Agriculture and Bioresources, and the Western College of Veterinary Medicine. The program's objective was to preserve the genetic diversity of Canadian livestock and poultry breeds, and to develop new techniques to conserve germplasm. This novel approach placed animal researchers from the Saskatoon Research Centre in the university environment. Cross-functional teams were formed with veterinary researchers in order to study genetic diversity, gamete and embryo biology, and cryobiology.

People and Programs: 2011

The Centre had 350 employees including 43 researchers, 21 post-doctoral fellows and 21 graduate students working in the following areas:

- Integrated crop management for sustainable cropping systems on the Canadian Prairies
- Sustainable management of clubroot infection in canola
- Integrated strategies for genetic improvement of oilseed and legume crops
- Genetic resource conservation, characterization and utilization
- Bioproducts and bioresources

The creation of new bioproducts and applications supported the diversification of agricultural production. The benefits to prairie agriculture included the development of effective bio-pesticides for weeds, plant disease, and insect pest control, and initiatives in bio-energy, bio-industrial chemicals, bioactive compounds, and bio-based materials from crop feedstocks (oilseeds, pulses and forages).

The scientific expertise within these major programs could be effectively mobilized to address industry issues as they emerged. For example, a multidisciplinary scientific team was assembled in 2009 to develop management strategies to tackle clubroot, a potentially devastating disease of canola.

Research highlights over the past 25 years

Integrated cropping systems

- Improved plant disease management strategies for direct-seeded and zero-till field crops to reduce the use of fungicides on prairie field crops
- Introduced a program to control wheat midge—one of the most comprehensive ever developed to manage a field-crop insect pest, now adopted across 4.5 million hectares of wheat production
- Introduced low-drift nozzle technologies that reduced spray drift by more than 75 percent
- Developed biological control strategies to conserve and sustain *Macroglenes penetrans*, a parasitic wasp and natural enemy of wheat midge; now controlling 30-40 percent of the wheat midge population annually
- Identified emerging weed problems at the species level, allowing producers to implement targeted weed management strategies earlier
- Used bio-climate models to assess the potential impact of climate change on the pest status of weeds, insects, and plant diseases, and to identify crops and agricultural regions most at risk

Genetic improvement of oilseed, forage and legume crops

- Developed improved varieties of canola, such as AC-H102, AC Excel, AC Elect, AC Parkland, AC Boreal and AC Sunshine
- Developed improved yellow, oriental, and brown mustard varieties, sustaining Canada as the leader in world condiment-mustard production
- Expanded through breeding the production of canola into hot, dry regions of Saskatchewan and southern Alberta, and established Canada as the world leader in the development and commercialization of canola

- Developed the world's first bloat-reducing alfalfa, AC Grazeland, which lowered the incidence of bloating in animals by up to 80 percent
- Developed improved forages such as AC Nordica (alfalfa), Radisson (smooth bromegrass), Kirk, AC Parkland and AC Goliath (crested wheatgrass), Fleet, Paddock and AC Armada (meadow bromegrass), and AC Knowles and AC Success (hybrid bromegrass)
- Carried out the sequencing of clubroot (*Plasmodiophora brassicae*), white rust (*Albugo candida*), blackleg (*Leptosphaeria maculans*), and stem rot (*Sclerotinia sclerotiorum*) genomes, which contributed to the development of disease management strategies

Genetic resource conservation

- Conserved 112,000 plant accessions representing more than 1,000 plant species, including the world's base collections of barley and oat, to preserve the world's biodiversity for agricultural traits used in crop improvement; also conserved 321,000 semen and 270 bovine-embryo samples from 19 different breeds, and 1,200 poultry samples of germplasm
- Developed new techniques to better conserve livestock breeds

Bioproducts and bioresources

- Registered the first bio-herbicide (*Colletotrichum gloeosporioides* f.sp. *malvae*) in Canada (in collaboration with Philom Bios), which established the regulatory and development model for commercial bio-pesticides in Canada
- Developed biodiesel fuel from canola oil extraction processes for City of Saskatoon buses
- Converted starch, protein, cellulose and fibre from biomass and grains into biofuels, bioplastics and other bioactive components, creating new value and market opportunities

- Developed a bio-herbicide (*Phoma macrostoma*) for broadleaved weed control in turfgrass (in collaboration with The Scotts Company) that reduces weed infestations by up to 90 percent
- Identified lignans in flax, and (using light-enhancement) produced dehydrosoyasaponin I, a rare medicinal ingredient, from chickpea extracts, for human health benefits

The Saskatoon Research Centre has contributed significantly to the development, management, and utilization of crop commodities grown on the Prairies. The Centre continues to develop and implement integrated crop management strategies that are ecologically sound, and to use traditional breeding strategies, coupled with modern biotechnology tools and approaches, to increase yield potential, enhance sustainability, and improve the quality of prairie crops. Further development of new bioproducts such as bio-pesticides, bio-industrial chemicals, bioactive compounds, and bio-based materials from crop feedstocks, and their applications continues to diversify agricultural products, open new market opportunities and stimulate agri-business activities.

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Melfort Research Farm
Melfort, Saskatchewan

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Since 1935, the research programs at Melfort have addressed the needs of the farmers and livestock producers of the Aspen Parkland of Western Canada. This area is characterized by some of the most fertile soils in the world, with adequate moisture for crop production but a limited number of frost-free and growing-degree days. The information gained in the forage-beef and field crops programs has been adopted by livestock and crop producers across the region to maximize economic returns by rationalizing inputs and mitigating pest problems in beef, forage and field crop production systems. Today, the Melfort Research Farm continues to assist Canadian crop producers and industry in improving production sustainability, notably through new varieties and improved agronomic and pest control practices using environmentally-friendly methods.

The early years, 1935–1985

The Melfort Experimental Station was opened in 1935. It is located in the Black and Gray-wooded soil zones of the Aspen Parkland region of Western Canada.

Research initially focused on weeds and soil erosion, which were identified as major problems related to crop production in the area. To support livestock production, the Experimental Station provided breeding services and sold purebred cattle to area farmers. Horticulture research and demonstration were also an integral part of the program at Melfort in the early years, continuing until 1970.

In the 1940s, Melfort conducted research and demonstration at nine illustration substations and three district experimental substations as well as at the main Farm. Livestock nutrition research was initiated in the 1950s and included evaluation of cattle rations in the feedlot, and pasture management systems.

In 1966, Melfort was renamed the Melfort Research Station. In the ensuing ten years, major additions to facilities were made, including the first hay-drying tower on the continent with an 80-ton capacity and a concrete stave silo. In 1974, a major pasture research project was initiated in the nearby Pathlow community pasture. The project led to the first "Pasture to Plate" forage-beef program in Canada.

In the 1960s, agronomic studies on cereals, forages and vegetables showned great increases in production with fertilizer use. A major variety-adaptation program evaluated cereals for the area. The first variety of sainfoin developed in Canada, named Melrose, was bred at Melfort in 1970, and forage produced under various systems was evaluated by feeding beef cattle. In the mid-1970s, research on the irrigation and harvesting of hay were shown to have merit, and Dormie, a variety of Kentucky bluegrass with superior winter hardiness, was developed and licensed in cooperation with the Saskatoon Research Station.

In the early 1980s, studies on the use of a roller herbicide applicator for control of brush re-growth were conducted, as well as studies to determine the energy requirement of forage system components.

The beginning of the second century of research, 1986–2011

In 1986, the forage-beef production systems program included studies on weed control, drought management and the fertilization of forage crops, forage handling and preservation, and ruminant nutrition. The cereal, oilseed and special crop production program included studies on crop production, weed control, tillage systems, crop rotation, soil fertility and nutrition, agronomy, and crop variety evaluation.

People and Programs: 1986

The Station had 47 employees including eleven researchers working in two programs:

- Forage-beef production systems: 7
- Cereal, oilseed and special crop production systems: 4

In the years after 1986, the research evolved to include forage crop production, evaluation, harvesting and handling, forage crop utilization by beef cattle and cow-calf operations, pasture management, and low-cost cow-calf grazing and wintering practices.

A renewed focus on crop production systems in 1988 included soil conservation research, the initiation of a plant pathology program, and studies to improve crop-harvesting technologies.

In the early 1990s, the Station's mandate was to develop and transfer environmentally and economically sustainable crop production technologies to farming systems for the Black and Gray soil zones of the northern Prairies. Soil conservation, forage crop production and annual crop management were the focuses of the research program.

In 1993, Melfort Research Station began reporting to the Saskatoon Research Centre, then was renamed the Melfort Research Farm and fully integrated into the Saskatoon Research Centre.

After the 1994 Program Review, the livestock program ended and the Farm's mandate focused on crop and forage production.

In 2001, as the Farm's research priorities changed, many of the facilities were retrofitted to facilitate field crop research or were dismantled once the livestock program ended. These facilities included the agronomy building, which became the field laboratory building, and the sheep barn, which became the seed-processing building, equipped with grain driers and seed cleaning facilities.

Sustainable cropping systems research has remained the mandate of the Melfort Research Farm. The programs have evolved since 1986 to focus on the general agronomy of cropping systems, the potential of new crops, and strong programs were established in integrated plant disease management as well as nutrient cycling and greenhouse gas research. The variety-development program has also remained an integral component of the research conducted at Melfort. Research examined practices aimed at the bio-economy, such as: the production of crops and crop varieties for fuel and fibre; improved soil, crop and nutrient management to improve soil quality and sustainability of production, as well as practices to reduce greenhouse gas emissions; and integrated management of plant diseases, such as blackleg of canola. Much of this research was conducted as multi-site, multi-year studies, in collaboration with departmental researchers throughout the Prairies, and in some cases, across the country, as well as with university and industry research staff.

Research Partners

Canadian universities:

Saskatchewan, Manitoba and Alberta

Federal and provincial government organizations:

Canadian Food Inspection Agency, Pesticide Management Regulatory Agency, Saskatchewan Ministry of Agriculture, Manitoba Agriculture, Food and Rural Revival, Alberta Agriculture and Rural Development

Other Canadian organizations:

Northeast Agriculture Research Foundation
Conservation Learning Centre
Canola Council of Canada
Saskatchewan Pulse Growers
Ducks Unlimited
Winter Cereal Growers
Western Grains Research Foundation
Saskatchewan Forage Seed Producers Association

International collaborators:

EMBRAPA, Brazil
INRA, France

Research highlights over the past 25 years

- Developed suitable cereal, oilseed and pulse cultivars for the region and experimented with potential new crops: quinoa, hemp, sorghum, camelina, calendula, prairie carnation, and canola
- Led the Pathlow Pasture project on pasture management and wintering studies with cows and their offspring; it became the first "Pasture to Plate" forage beef program in Canada

- Improved production practices, such as reduced tillage systems, which have been widely adopted by farmers, have had significant and long-lasting impacts on the environmental sustainability of soils and have improved the economics of crop production
- Enhanced the understanding of blackleg disease of canola in order to spur the development of mitigation strategies
- Integrated nutrient management for improved production, product quality and economic returns, and enhanced nutrient-use efficiency and soil quality with a minimum of nutrient loss and damage to the environment
- Determined the impact of fertilizer input level, cropping diversity, and crop species on accumulation and distribution of nutrients in the soil profile

In 2011, the Melfort Research Farm had 14 employees including three researchers, technicians and administrative staff, as well as a number of visiting scientists and students. The research programs have addressed the needs of farmers and livestock producers in the unique environment of the Aspen Parkland of Western Canada. The information gained in the forage-beef and field crops programs has been adopted by livestock and crop producers across the region. The Farm continues to help Canadian crop producers and industry to improve production sustainability, notably through new varieties, and through improved agronomic and pest control practices using environmentally-friendly methods.

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Scott Research Farm
Scott, Saskatchewan

Eric Johnson, Biologist, Research Branch, Scott

Established in 1910, the Scott Research Farm, originally known as the Scott Experimental Station and renamed the Scott Experimental Farm in 1959, has contributed to the crop production sector with research on conservation tillage, weed control, and diversified cropping systems. The award-winning Alternative Cropping Study, initiated in 1994, is the Farm's flagship study. This comprehensive, multi-disciplinary study demonstrates to farmers the economic and environmental sustainability of alternative cropping systems that employ varying levels of inputs and cropping diversity. The Minor Use Pesticides Program, initiated in 2002, has generated field data that has led to more than 70 minor use pesticide registrations and submissions. Today, the Farm continues to focus on cultivar evaluation, soil and crop management, weed management and pesticide minor use. It also maintains its role in the development of Camelina sativa and Brassica carinata, two potential oilseed crops.

The early years, 1910–1985

The Scott Experimental Station (known today as the Scott Research Farm) was established in 1910 to serve western Saskatchewan from the South Saskatchewan River to the northern forest, as well as a portion of northeastern Alberta. Initial emphasis was on helping settlers adapt to the soils and climate in the region. Later, the emphasis shifted to improving crops and livestock and their husbandry, as well as improving farmsteads. The original land base was 43 hectares.

The first 25 years at the Farm witnessed the planting of orchards, testing of cereal and horticulture crops, and the introduction of a cattle herd, poultry flock, and sheep and swine herds. A purebred breeding program of dual-purpose Shorthorn cattle was initiated in 1921. Crop rotations were established and have continued on the same land area since 1911. Illustration stations came into effect at that time, and Scott was responsible for nine stations in northwest Saskatchewan. These stations were instrumental in establishing practices to reduce the severe soil erosion that occurred during the 1930s. The Rescue crab apple, one of the most common crab apple cultivars on the Prairies, was selected at the Scott Experimental Station during this era.

More land was acquired over time, and the construction of new buildings continued until about 1950. By that time, the land base was 465 hectares of Crown land and 190 hectares of leased land. A dam to supply water for livestock was constructed. In 1955, Scott was chosen as the Potato Isolation Station for the Prairies. Two potato cultivars, Batoche and Carlton, were licensed from selections made at the Farm. The apple cultivar Norland was also selected in the horticulture program. In 1960, research projects on animal husbandry ended.

The Scott Experimental Station was renamed the Scott Experimental Farm in 1959, and became a research field site of the Saskatoon Research Station in 1971, but without professional staff on the premises until 1978. The work of the two researchers appointed at the Farm resulted in significant research accomplishments in the areas of soil fertility, weed management, and conservation farming.

The beginning of the second century of research, 1986–2011

Research efforts remained relatively stable from 1986 to 1994, even though the Farm's land base had declined to 338 hectares. External funding provided extra resources for research, and several new employees were hired on short-term agreements. Obsolete field and laboratory equipment was replaced. The Farm was renamed the Scott Research Farm in 1994 and was fully integrated into the Saskatoon Research Centre.

People and Programs: 1986

The Scott Experimental Farm had 25 employees.

Research was supervised by four researchers, two located in Scott and two in Saskatoon. Programs included weed management, soil and crop management, soil fertility and cereal cultivar evaluation.

Scott had four project farms: Kindersley (Dark Brown soil zone), Lashburn (Black soil zone), Glaslyn (Grey-Black soil transition zone) and Loon Lake (Grey soil zone).

Studies on the form, timing and placement of nitrogen fertilizer made significant contributions to improving nitrogen fertilizer efficiency. In response to concerns about declining soil quality on the Prairies, the Farm was an active participant in crop management research to reduce soil degradation. Numerous studies were initiated on minimum- or zero tillage, extended rotations, and the benefits of diverse crop rotations. The rapid adoption of conservation tillage by Prairie farmers was the result of research from public and private institutions, as well as effective technology transfer through producer organizations such as the Saskatchewan Soil Conservation Association, provincial government extension services, and industry agronomists.

A comprehensive interdisciplinary study called the Alternative Cropping Study, involving 15 to 20 researchers from across the Prairies, was initiated in 1994. The study was designed to address a number of threats to sustainable crop production, notably soil degradation, high and increasing inputs of energy, nutrients and pesticides, declining biodiversity, and economic constraints. The study demonstrated to producers the impact of alternative cropping systems on sustainability, and identified the strengths and weaknesses of cropping systems that employ varying levels of inputs and cropping diversity.

Field Day

The Scott Field Day has been held annually since 1980, and continues to draw more than 200 visitors to the Farm each year. In addition, the Farm hosts field tours for organic producers, extension specialists and industry agronomists on a periodic basis. In 2010, the Farm commemorated its 100th anniversary with the publication of a history book and the hosting of a successful centennial celebration that attracted more than 350 people.

In 1996, the federal and provincial governments began a cooperative agreement that located one provincial employee at the Farm part-time. The agreement proved a very effective way to ensure technology transfer, and it remains in place to this day.

The Farm participated as a "site" in the specialized crop area of the Canada-Saskatchewan Agri-Food Innovation Fund from 1997 to 2002. Since 2003, the Farm has participated as an Agri-ARM (Agriculture-Applied Research Management) site with provincial government support. This participation led to the creation of the Western Applied Research Corporation, a farmer group that facilitates external funding of projects and provides guidance on research and extension activities.

A new multi-purpose building was constructed in 1998 to replace aging infrastructure. It comprises offices, laboratories, a greenhouse and a maintenance shop, and remains highly functional today. A number of old buildings were no longer needed and were removed.

The Farm became a test site for the Minor Use Pesticides Program in 2002. Scott became one of nine federal minor use pesticide test sites in Canada with responsibility for the Prairies. Since 2002, about 250 trials have been conducted on more than 50 crop types involving 73 herbicides, fungicides, and insecticides. This has led to a significant number of pesticide registrations on crops such as perennial legumes and grasses grown for seed and forage production, annual legumes, herbs and spices, oilseeds, small fruits, and vegetables. Herbicide screening led to the introduction and registration of two herbicides with modes of action that are novel to the Prairies.

In 2006, the project farms at Loon Lake and Lashburn were closed, and a farm was re-established at Glaslyn. The research at Glaslyn focuses on cultivar evaluation in an environment with a short growing season. Over the past decade, many of the Farm's studies have been multi-disciplinary, multi-site and multi-year experiments, with funding from multiple levels of government and from industry partners. An example is the Prairie Canola Agronomic Research Program, which supports the development of prairie-wide canola agronomic studies and is supported by the three prairie canola development commissions. Science Clusters and the Developing Innovative Agri-Products program under Growing Forward provide support for collaborative studies in canola, mustard, pulses, barley, and winter wheat.

People and Programs: 2011

The current staff at Scott Research Farm includes one researcher, a Pesticide Minor Use principal investigator, an administrator, a maintenance technician, and six technicians.

Research highlights over the past 25 years

- Developed knowledge and tools related to tillage, weed management, fertilizer application, and cropping sequences that allowed producers to adopt conservation farming and no-till practices—the most significant accomplishment in prairie agriculture of the past 25 years

- Contributed through agronomic, crop-protection, and crop-adaptation research to the reduction of summer fallow acreage and the diversification of the Saskatchewan farm economy through grower adoption of oilseed, pulse and special crops production
- Led the Alternative Cropping Study, which has provided growers with information on the economics, energy-use efficiency and environmental sustainability of various input systems (high, reduced and organic) and cropping diversities
- Conducted the first North American field trials on Roundup Ready canola in 1988. Effective weed control in herbicide-tolerant canola allowed for early seeding, resulting in early flowering prior to mid-summer heat stress
- Illustrated the benefits of hybrid canola in terms of productivity, stress tolerance and nitrogen-use efficiency
- Conducted minor use pesticide field trials, which have led to 35 minor use registrations and an additional 42 submissions
- Formulated recommendations for growers to achieve cost-effective weed control while minimizing environmental impact, based on research on herbicide rates, timing, and application parameters
- Developed weed management strategies for organic producers based on mechanical weed control studies

Currently, as an important part of the Saskatoon Research Centre, the Scott Research Farm focuses on four program areas: cultivar evaluation, soil and crop management, weed management and pesticide minor use. Research is focused on the following areas: herbicide resistance and mustard agronomy, development of Ethiopian mustard (*Brassica carinata*) into an industrial oilseed crop, management of herbicide resistance in pulse crops, malting barley agronomy and canola agronomy. With support from Saskatchewan Agriculture and industry, the Farm is also responsible for agronomic research in the development of *Camelina*, a potential new oilseed crop for the Prairies.

Semi-arid Prairie Agricultural Research Centre
Swift Current, Saskatchewan

Tom McCaig, Mike Schellenberg and Robert Zentner, Research Scientists, Research Branch, Swift Current

Since 1920, federal agriculture researchers in Swift Current have contributed to the improvement of the Canadian prairie agricultural sector through the development of new cultivars, knowledge, and technologies in the areas of cereals, forages, soils, the environment, and engineering. Significant scientific progress occurred in the areas of pasture management, diversification, tillage and alternative cropping practices, physiology, molecular biological applications, and plot machinery design. The Centre remains the major research facility directly addressing the problems of the semi-arid prairie region, notably managing and adapting agriculture to a dry, unique environment in response to changing regional, national, and international food and fiber production and marketing conditions.

The early years, 1920–1985

Agriculture problems in the severe-drought areas of southern Saskatchewan and Alberta (known as the Palliser Triangle) were addressed when the Department of Agriculture purchased land adjacent to Swift Current in 1920 as the site for a new experimental station.

The timing was auspicious, as researchers hired at the Swift Current Experimental Station were immediately faced with the longest period of drought the region had seen in 100 years. Farming practices of 1920 could not effectively cope with the consequences of the droughts of the 1920s and 1930s, and widespread soil drifting and farmland abandonment took place across the Great Plains.

Research at Swift Current soon focused on improving the efficiency of trapping, conserving and utilizing the small amount of moisture available. Types and varieties of crops were studied to learn which ones could better withstand drought conditions and at the same time produce enough fodder for livestock. Early research demonstrated that farmers must work their fields at the proper time, with equipment such as the wideblade cultivator rather than the mouldboard plow, to conserve surface crop residue and help protect the soil from wind erosion. In addition, it showed that some areas should be returned to grass; stubble from the previous year's crop and dead weeds from fallow land should be left standing on the soil surface to trap snow and prevent soil from blowing; and when soil started to blow, farmers must take immediate action to prevent further damage by ridging soil at right angles to the direction of the wind. All this information was gathered and published for farmers in 1934.

The Station included extensive machine-shop facilities, constructed in the 1950s, reflecting a strong history of machine design, modification, construction, and maintenance. In 1965, the Experimental Station was renamed the Swift Current Research Station. A new research building, completed in 1965, incorporated fully serviced laboratories, offices, environmentally-controlled growth rooms, administration offices, a library, drafting and photography studios, greenhouses and greenhouse header-house facilities, and computer and meeting rooms.

Over the years, the number of researchers at Swift Current has varied. For the first 14 years, there were no more than seven researchers conducting research. Between 1935 and 1950, the number of researchers increased to 35, but between 1950 and 1985, the number decreased to 25.

People and Programs: 1986

The Swift Current Research Station had 25 researchers working in the following areas:

- Cereals production and utilization: 8
- Engineering: 6
- Forage production and utilization: 5
- Soils and environment: 6

The beginning of the second century of research, 1986–2011

In 1986, the facilities were also equipped with a meteorological site and wind turbine. In 1988-1989, the only salinity-tolerance testing laboratory (SaltLab) in Canada was built at the Station. In 1993-1994, a new crops services building was constructed to accommodate laboratory and service areas. A new building was also built to facilitate the safe storage and disposition of pesticides and herbicides.

By 1992, responsibility for administering the Indian Head Experimental Farm was transferred to the Swift Current Research Station. It quickly became an essential resource for most of the research at Swift Current. Shortly after the closure of the Regina Research Station in 1995, the Regina Research Farm was established on site as a crucial test location for the wheat breeding programs centreed at Swift Current. The name of the Swift Current Research Centre was changed to the Semi-arid Prairie Agricultural Research Centre (SPARC) in 1995 to better reflect its regional mandate and responsibilities. That same year, a new conference and meeting room facility was constructed with an enclosed link to the main building. The Saskatchewan Land Resources Unit in Saskatoon reported to SPARC from 1996 until responsibility was transferred to the Saskatoon Research Centre in 2003.

A transfer of 106 hectares of Crown land was made to the city of Swift Current in 1995 in exchange for 130 hectares of city land adjacent to the main field research areas southwest of the Centre. This exchange greatly benefited the city while providing agricultural land to the research centre that was much better suited to annual crop research.

A major strength of the Centre is its research land base of 930 hectares, of which forage research uses about 575 hectares. An additional 140 hectares consists of native grassland, considered an endangered habitat. The balance of the land base is devoted to small-plot agronomic research and cultivar development.

In the first decade of the 2000s, research supported the broad movement away from frequent summer fallowing and monoculture cereal cropping using conventional mechanical tillage and toward more continuous cropping systems that use mixed cereal-oilseed-legume rotations together with conservation tillage management. Research proposals are peer-reviewed, funding is more precisely targeted, and the industry-led Agri-Science Clusters and Developing Innovative Agri-Products initiatives encourage more industry leadership and investment in research.

Research from the SaltLab allowed SPARC researchers and engineers, in cooperation with colleagues at the United States Salinity Laboratory, to revise the 25-year-old conventional threshold-slope model for crop tolerance of root-zone salinity and replace it with an equation that more precisely reflects the gradual decrease in crop production as salinity increases from negligible. This equation led to the development of the increasingly popular Salinity Tolerance Index, which has been applied to most crops including those grown and evaluated in the SaltLab (wheat, barley, canola, mustard, peas, lentils, beans, camelina, forage grasses, alfalfa, and hybrid poplars). These evaluations identified selected canola cultivars as equal in salinity tolerance to barley and led to the development of a new forage grass (AC Saltlander green wheatgrass). Recent evaluations have resulted in new salt-tolerant alfalfa varieties being released.

Swift Current researchers have played a leading role in research and development and the validation of soil and crop models (e.g. SPARC wheat) and decision-support systems for use across the Canadian Prairies.

The long-term-rotation field experimental plots at Swift Current have provided a significant proportion of the quantitative and qualitative information used to assess sustainable production, greenhouse gas emissions, net returns/risk and energy use, as well as the impacts of climate change.

People and Programs: 2011

The Semi-arid Prairie Agricultural Research Centre had 18 researchers working at Swift Current in the following areas:

- Innovation and science: 10
- Environment: 7
- Food safety and quality: 1

Cereals research at SPARC has focused on a team approach to cultivar development, bringing together researchers working in the areas of agronomy, physiology, plant and insect pathology, breeding, biotechnology, cereal chemistry, statistics, and data management. For example, SPARC was among the first wheat breeding programs to develop registered cultivars through the implementation of marker-assisted selection and doubled-haploid technology.

Activities in engineering research have focused on conservation tillage equipment design, evaluation, cooperation, and engineering design to support the research of all the programs at SPARC as well as programs at other centres in Western Canada. Additionally, the engineering expertise developed in the semi-arid prairies has contributed substantially to international efforts in India, Pakistan, Brazil, Egypt and China.

Research highlights over the past 25 years

Forages

- Developed improved cultivars of Russian wildrye, Altai wildrye, dahurian wild rye, and alfalfa
- Developed ecological varieties for native species, including awned wheatgrass, little blue stem, northern wheatgrass, western wheatgrass, rough fescue and Canadian milkvetch
- Demonstrated the benefits of diversifying seeding mixtures and the contributions of seeding native plant species to livestock production

- Tested new legume and grass varieties under grazing scenarios to improve selection and identify preferences
- Contributed to pasture rejuvenation through fertilization or inclusion of perennial legumes

Soils and environment

- Developed conservation tillage practices to minimize soil disturbance for annual cereal, oilseed and pulse crops, to increase crop yields, conserve soil moisture, enhance soil organic matter and soil carbon sequestration levels, reduce greenhouse gas emissions, protect the soil from wind and water erosion, and increase energy-use efficiency and economic returns; these practices have been adopted by cereal, oilseed, and pulse farmers
- Determined the long-term impacts of alternative cropping practices (e.g. fallow frequency, crop type and method of tillage) on soil, water, and air quality
- Developed management practices for new and alternative oilseed and pulse crops suited to the semi-arid region
- Developed crop residue conservation methods to reduce soil erosion, increase soil water, and maintain/enhance soil organic matter
- Developed cropping systems that reduce summer fallowing and incorporate oilseed and pulse crops into monoculture cereal rotations
- Developed fertilizer management techniques for annual crops to enhance grain yield and quality
- Developed management techniques to enhance snow trapping and soil moisture conservation

Cereal cultivar development

- Developed a total of 48 new cereal cultivars, including the following varieties: 17 Hard Red Spring wheat; nine Canada Prairie Spring wheat; two Hard White wheat; nine durum wheat; seven triticale; three winter rye; and one general purpose wheat

- Developed Canada Western Red Spring cultivars, including AC Barrie and Lillian; on average these cultivars are grown on more than 50 percent of the area sown to Hard Red Spring wheat on the Prairies each year
- Developed Canada Western Amber durum cultivars, including Kyle and AC Avonlea; these cultivars represent approximately 70 percent of the world trade in durum wheat
- Developed the low-cadmium wheat cultivar, Strongfield, which is the most widely grown durum cultivar since 2007

Engineering

- Developed self-propelled plot seeders that significantly improved the speed, accuracy and reliability of seeding the tens of thousands of plots established each year at research centres
- Developed plot trimmers for cereal and forage plots that have significantly improved accuracy of yield measurements while reducing labour requirements
- Developed a system to measure the methane produced by cattle

The agricultural researchers in Swift Current have made major contributions to the improvement of the Canadian prairie agricultural sector through the development and application of new cultivars as well as knowledge and technologies with respect to cereals, forages, soils, the environment and engineering. SPARC remains the only major agricultural research facility directly addressing the problems of the semi-arid prairie region, notably the management and adaptation of agriculture to a dry, unique environment in response to changing regional, national, and international food and fibre production and marketing conditions.

Regina Research Farm
Regina, Saskatchewan

Tom McCaig, Research Scientist, Research Branch, Swift Current

The Department of Agriculture established an Experimental Substation in Regina in 1931 that reported to Swift Current and was mandated to work on the problems of soil drifting, weed control, and crop rotation in heavy clay soils. Research was conducted to find appropriate seeding and summer fallow practices for the eradication of weeds. Regina became an Experimental Farm in 1954 and a Research Station in 1962 conducting three research programs: weed control research, cereal breeding, and seed increase of new cereal and forage crop varieties. These programs were gradually moved to other centres, and the Station was closed in 1995. However, a Research Farm was maintained on some of the land, and it continues to support research programs based at Swift Current. In 2011, the Regina Research Farm was providing a field test site, which has proven valuable to the genetic enhancement of cereals in Western Canada.

The early years, 1931–1985

Traditional farming practices could not effectively cope with the periods of drought and the widespread soil-drifting that occurred across the Great Plains in the 1920s and 1930s. To address these issues, the Department of Agriculture established, in 1931, an Experimental Substation at Regina (reporting to Swift Current) to work on the problems of soil-drifting, weed control, and crop rotation in heavy clay soils.

Research was immediately undertaken to find appropriate seeding and summer fallow practices for the eradication of weeds. Experiments with herbicides were carried out for the control of wild mustard, stinkweed and perennial weeds in a variety of cereal, oil seed, and forage crops. Weed ecology studies were undertaken to observe how weed populations were affected by various tillage and cropping practices.

The use of cultivators and the practice of maintaining trash cover on the soil surface essentially eliminated the problem of erosion of soil by wind, and the wild mustard problem on the Regina Plains appeared to be solved with the introduction of 2,4-D in 1945. The success of this herbicide on wild mustard led to further research to find ways to control other weeds that plagued prairie farmers. Regina substation became an Experimental Farm in 1954.

A wheat breeding program was established in 1951 to develop sawfly-resistant (solid stem), rust-resistant bread wheat varieties; by 1960 it was also focusing on durum wheat. The Regina Experimental Farm became the departmental focal point for the seed increase of newly developed cereal and forage varieties for distribution after licensing. This led to the building of the seed plant in 1957.

In the early 1960s, the Regina Experimental Farm conducted weed control research and cereal breeding, and increased the seed of new cereal and forage crop varieties being developed by Research Branch. It became a Research Station in 1962.

From the mid-1960s to the mid-1980s, the weed research program conducted studies in agronomy, ecology, plant physiology, biochemistry, soil science, and chemistry.

In 1970, wheat breeding programs, including the Regina wheat program, were consolidated in Swift Current. In 1985, the Seed Increase Unit was transferred to Indian Head.

The beginning of the second century of research, 1986–2011

In 1986, Regina researchers focused on the biology and control of weeds in cultivated crops and pastures. Research was conducted into the biological control of weeds, weed ecology and physiology, and herbicide behaviour in the environment.

People and Programs: 1986

The Regina Research Station had 14 researchers, one visiting researcher, and two graduate students working in three sections:

- Biological control of weeds: 4
- Weed ecology and physiology: 6
- Herbicide behaviour in the environment: 4

Researchers carried out projects on biological control, weed surveys, crop loss, plant physiology, and herbicide chemistry in the environment. Many of these projects were national in scope. The Regina researchers played a role in the development of zero- and minimum-tillage practices, as well as promoting a reduction in the use of summer fallow, especially as related to the judicious use of chemicals for weed control. Models were developed to predict the economic losses caused by various weeds, and the expected returns offered by the various options available. Long-term studies examined the soil residues and breakdown products of a multitude of farm chemicals—including 2,4-D and glyphosate—in cereals, oilseeds, forages, and many special and minor crops. Collectively, the focus of research was on improving the effectiveness of weed control, reducing dependence on pesticides, improving personal safety measures for farmers with respect to pesticide use, helping ensure food safety for the consuming public, and promoting a safe, sustainable environment.

The research was reorganized from three areas to four in 1991. These were biological control of weeds, environmental chemistry-application technology, weed biology, and integrated weed and crop management.

Between 1991 and 1993, science programs were transferred to other research establishments, especially Saskatoon. At the same time, Indian Head Experimental Farm began to report to Swift Current.

The Regina Research Station was closed in 1995, having served Canadian agriculture for about 64 years. However, due to the importance of the location as a test site for the Department's wheat breeding programs, the Regina Research Farm was established on 40 hectares of the same site in 1995.

Research highlights over the past 25 years

- Developed chemical herbicides to resolve problems concerning weed control, soil erosion, and limited soil moisture
- Developed zero- and minimum-tillage practices, along with reduced summer fallow, as related to the judicious use of chemicals for weed control
- Developed models to predict economic losses caused by various weeds and the expected returns of the various available options
- Developed safer production systems for the control of weeds that integrated all means—chemical, biological, and cultural—with the objectives of minimizing the amount of herbicide introduced into the environment and protecting Canada's food supply
- Released more than 30 insect species as potential biological control agents for a multitude of weed species in eight provinces
- Discovered and developed the fungus (*Colletotrichum gloeosporioides* f.sp. *malvae*) that became the first bio-herbicide (round-leaved mallow) registered for use in Canada, and which provided the model for future bio-herbicide registrations
- Made significant progress on the biological control of knapweed and leafy spurge with the release of host-specific phytophagous insects

- Investigated the hazards to which herbicide sprayer operators were exposed while handling herbicides, and successfully developed the means to minimize those hazards
- Undertook testing to contribute to successful durum wheat cultivars, such as Wascana, Wakooma and Kyle

Although reduced in capacity, the Regina Research Farm provides a valuable field test site that has proven crucial to the genetic enhancement of cereals in Western Canada. The Agri-Environment Services Branch also uses about 160 hectares at the Regina site.

Indian Head Research Farm
Indian Head, Saskatchewan

Guy Lafond, Research Scientist, Research Branch, Indian Head
David Gehl, Officer in Charge, Research Branch, Indian Head

The Indian Head Research Farm, originally known as the Indian Head Experimental Farm, was one of the five original agricultural research sites that the federal government established across Canada in 1886. Over the years, the activities at Indian Head have changed, but the focus has remained on supporting the agricultural industry in matters of seed production, variety development and evaluation, and soil and crop management research. Researchers also work in the areas of soil, air and water quality, and sustainability. The Farm continues to play an important role in agronomy research, variety development, and seed production, and continues to support the producers of the region.

The early years, 1886–1985

The Indian Head Experimental Farm, as it was known at the time, was one of the five original agricultural research sites established by the federal government in 1886. Its role was to provide immediate support to the settlers moving west, many of whom had little farming experience. Researchers provided support and information regarding the crops and varieties—cereal grains, oilseeds, vegetables, fruit trees, and forage species—that were best adapted to the area, as well as basic knowledge of soil management and crop production. Farm staff also provided settlers access to knowledge about animal care, nutrition and genetics for horses, beef and dairy cattle, hogs, and chickens.

During the Depression of the 1930s, Indian Head was the research farm most deeply involved in combating the blowing soil of the Dust Bowl that characterized that decade on the Prairies.

In 1972, the Farm started reporting to the Regina Research Station. The Seed Increase Unit from Regina was transferred to Indian Head in 1984. Its research expanded into the areas of special crops and weed control, and then production systems, with special focus on the research of innovative soil conservation practices.

These efforts coincided with the release in 1984 of *Soils at Risk, Canada's Eroding Future* by the Senate Standing Committee on Agriculture, Fisheries, and Forestry, which greatly heightened the awareness among Canadians of the serious issue of soil degradation in Canada. This led to federal-provincial initiatives such as the 1985 Canada-Saskatchewan Economic and Regional Development Agreement (ERDA) aimed at winter wheat production, which brought additional resources (people and equipment) to the issue. The emphasis on winter wheat was viewed as the first step toward making producers familiar with no-till production practices, given the requirements of seeding winter wheat into standing stubble.

The beginning of the second century of research, 1986–2011

The agronomy research that began in the early 1980s was closely followed by a second five-year research initiative that started in 1986 and involved a funding partnership between ERDA, Hoechst Canada Inc. and the Indian Head Experimental Farm. This led to the creation of the East Central Saskatchewan Soil Conservation Project, which provided much needed information on the important contribution of innovative tillage and cropping systems to the protection of soils from wind and water erosion. Other programs, such as the National Soil Conservation Program of 1989, provided producer groups with funds to try the new practices first-hand.

The funding also provided support to producer associations whose focus was soil conservation, including the Soil Conservation Council of Canada, the Saskatchewan Soil Conservation Association, the Manitoba-North Dakota Zero Tillage Farmers Association, the Alberta Conservation Tillage Society, Reduced Tillage Linkages, and others.

In 1991, the five-year Parkland Agricultural Research Initiative was established to further enhance soil conservation practices in the Black soil zone, where the Farm is located. This funding allowed for an even greater opportunity to probe the potential of no-till production systems.

During this time, the Western Grains Research Foundation was established with its Endowment Fund. Other commodity groups, such as those for the pulse growers, canola growers and flax growers, also started collecting levies to support research and leveraging federal and provincial funding. This had the effect of greatly accelerating research and provided more support for the agronomy research programs at Indian Head.

Leveraging Funding for Growth

In 1993, local producers from the Indian Head area incorporated the Indian Head Agricultural Research Foundation (IHARF) as a non-profit organization. Over the years, IHARF has received funding through various components of the Canada-Saskatchewan Agri-Food Innovation Fund to allow it to purchase field and research equipment, and to construct a building to house equipment. Funding also made possible the expansion of research, notably of projects related to precision farming and to the development of field-scale agronomy research. Research projects were also initiated through joint funding arrangements between IHARF and the Agri-Food R&D Matching Investment Initiative, and between IHARF and the federal Environment Technology Assessment for Agriculture program. As of 2011, IHARF had invested more than $1 million in buildings and field- and plot research equipment, while providing additional financial support to agronomy research.

Since 1986, researchers at Indian Head had been testing regional grain varieties and had been responsible for two small off-station testing sites at Yorkton and Arcola, Saskatchewan. In 1989, testing at these two sites was discontinued. This reduction was offset by an increase in on-station testing involving regional trials of spring wheat, barley, oat, durum, and flax, as well as the testing of advanced flax lines in the flax wilt nursery. In 1991, the program underwent a major expansion and became an integral part of the Arid Prairie Wheat Breeding Program, headquartered at the Swift Current Research Station.

In 1992, administrative responsibility for the Indian Head Experimental Farm was transferred to Swift Current, and was renamed the Indian Head Research Farm a year later. In 1995, the agronomy research program was consolidated at the Brandon Research Centre, which became the focal point for soil and agronomy research for the Black soil zone.

In 2000, Research Branch management recognized the need to maintain an agronomy research presence at Indian Head, and that program was moved back from Brandon. Thereafter, the Farm encompassed three programs, the Seed Increase Unit, the Arid Prairie Wheat Breeding Program and the Agronomy Research Program, supported by 500 hectares of arable land owned and operated by the Farm.

The Seed Increase Unit (SIU) is an officially certified "registered seed establishment," with a national mandate to produce, maintain and distribute breeder seed of crop varieties developed by departmental plant breeders, and to co-ordinate winter nursery activities for Research Branch. The Seed Increase Unit, which had originally been located in Regina, moved to the current location at Indian Head in 1984. Successful varieties of durum, wheat, oat, barley, flax, pulses, and other crops developed by departmental researchers are sent to Indian Head for propagation. The SIU propagates breeder seed of new cultivars and distributes it to pedigreed seed growers, who in turn grow the varieties and sell them to farmers as certified seed. The SIU is the largest single source of breeder seed in the Canadian pedigreed seed system. The SIU's current inventory includes more than 300 registered varieties of 42 crops, reflecting the Department's leading role in plant breeding of field crops. These crops include cereals, oilseeds, pulses, forage legumes, grasses, and special crops.

The Arid Prairie Wheat Breeding Program conducts research on more than 20,000 plots. In addition to conducting regional and cooperative trials involving oat, barley, spring and winter wheat, durum, triticale, flax, and field pea, the program is also responsible for early-generation testing of Canada Prairie-, Hard Red- and Hard White Spring wheat and durum, as well as testing of field pea for the University of Saskatchewan and the Manitoba Pulse Growers, and of oat for the University of Saskatchewan. During the winter months, the staff runs a greenhouse nursery in order to conduct early-generation testing of spring wheat, barley and durum lines exhibiting genetic resistance to loose smut.

The expansion of the cereal breeding program at Indian Head is in part due to the wheat and barley check-off that was created and is administered by the Western Grains Research Foundation. The check-off is a refundable levy charged to producers in support of research into wheat and barley breeding. Since 1986, the program has quadrupled the number of plots established each year, not including the greenhouse work in the winter.

As for the Agronomy Research Program, soil conservation research has evolved in light of broader agri-environmental issues, as reflected in initiatives such as the Green Plan, the Agri-Food Innovation Fund in Saskatchewan, the Canadian Adaptation and Rural Development Fund, and the Greenhouse Gas Mitigation Program. Detailed research was undertaken over a period of six years, starting in 2000, to determine how the management of nitrogen fertilizers and cropping systems affect the production of nitrous oxide emissions, which are responsible for approximately 60 percent of on-farm greenhouse gas emissions in Canada.

Research highlights over the past 25 years

- Produced more than 900 breeder seed lots since 1990; these have formed the basis of pedigreed seed production of these varieties, and subsequent commercial production on millions of hectares across Canada
- Developed advanced methods of seed production and seed storage to ensure a supply of high-quality breeder seed to commercial pedigreed seed growers

- Showed that the protocol developed to test for the presence of glyphosate-tolerant off-types in spring wheat breeder plots (in order to maintain genetically-modified-free status of the breeder seed stock) resulted in the complete absence of glyphosate-tolerant plants after a seven-year period
- Showed in a 14-year study that there was no interaction between tillage systems and crop rotation; this implies that the accumulated knowledge of crop rotation under conventional tillage also applies to no-till
- Demonstrated the positive economic and energy benefits of no-till relative to conventional tillage
- Revealed the significant and continued improvements of no-till on soil productivity following studies comparing long-term no-till (more than 31 years) to short-term no-till (less than 10 years)
- Demonstrated for the first time the agronomic feasibility of using anhydrous ammonia in a one-pass seeding and fertilizing no-till system for spring wheat and canola
- Showed that it was possible to use a row-spacing greater than the accepted 20 centimetres, and up to 30 centimetres, without incurring a yield loss in spring wheat, winter wheat, durum, barley, oat or flax
- Demonstrated that split-nitrogen applications on spring wheat, canola, durum, oat and barley could be used successfully, provided that 50 percent or more of the target nitrogen rate was used at seeding
- Developed and field tested, in conjunction with the Indian Head Agricultural Research Foundation, application algorithms for spring wheat and canola that work with optical sensors and can apply liquid fertilizer nitrogen in real time, while taking into consideration spatial and temporal variability
- Showed that 50 years of straw removal did not affect soil organic carbon, providing much needed information for the cellulosic ethanol industry

- Evaluated various crop protection products under the Minor Use Pesticides Program and in collaboration with the Indian Head Agricultural Research Foundation; this led to the registration of crop-protection products for canary seed, foxtail millet, coriander, caraway, sunflower, and niger

The Indian Head Research Farm is an important location for agronomy research, variety development and seed production. It continues to support the agricultural industry and the producers of the region, and remains actively involved in the network of departmental sites in Western Canada. The current structure allows for the evaluation and development of technologies at the small plot-, large plot- and field-scale levels. As a result of its large land base and easy access to additional land in close proximity, the Farm also provides leadership in the development and testing of applications pertaining to robotics, remote sensing, harvest management, grain storage technology, cropping systems, and cultivar development, testing, and increase.

Lacombe Research Centre
Lacombe, Alberta

Rick Lawrence, Research Manager, Research Branch, Lacombe
Debbie Olsen, Laboratory Technician, Research Branch, Lacombe

Established in 1907, the Lacombe Research Centre, formerly known as the Lacombe Experimental Station, has played a key role in supporting advances in the animal and crop sectors in Canada. Over the years, Lacombe has focused on research in the meat value chain, increasing knowledge of the production factors influencing meat quality and safety, such as animal welfare and forage-beef interaction. It has also expanded knowledge of carcass and meat quality, safety, microbiology and virology; bovine genomics; as well as the interaction between these disciplines. At the same time, the Centre has focused on integrated crop management systems, including agronomic factors, weeds, and plant pathology specific to the environment of the Parkland and Northern regions.

The early years, 1907–1985

The Lacombe Experimental Station was established in 1907, with six employees, on the same quarter section of land that it currently occupies. At the beginning, researchers at Lacombe conducted research on horticultural and field crops, bees, sheep, swine, horses, dairy and beef cattle, and meat. Many of the citizens of Lacombe still recall its horse and cattle shows, as well as the Lacombe Hog, developed in the swine breeding program in the 1950s.

The Station began to investigate carcass quality at that time. In 1959, the Experimental Station was renamed the Lacombe Research Station. By 1968, the Station had assisted in the development of a new hog grading system, and by 1972 had set up a national beef carcass grading system. Over the next decade and a half, the Station developed a meat research group that conducted research on aspects of the meat value chain from production to sensory analysis.

From the 1950s to the 1980s, plant research shifted away from the horticultural crops, such as new breeds of tomatoes and apples, and toward the breeding and management of field crops, such as oats, barley and canola. A number of new oat varieties originated in Lacombe during those years, and there was an increasing focus on plant pathology, weeds and soil research, and agronomic practices that enhance plant production.

In 1984, the Department built a federally certified research abattoir that could handle up to 20 cattle or 40 swine per week. Its capabilities included complete carcass cutout to enable the assessment of meat quality and yield. Together, these new facilities and the existing beef and swine units made Lacombe a unique research facility in Canada: it was one of only a few sites recognized internationally for the ability to assess the impact of production and processing factors along the entire meat production chain, from animal conception to meat consumption.

The beginning of the second century of research, 1986–2011

With the addition of the new abattoir and laboratory, and with the support of the beef and swine production units at Lacombe, researchers conducted

People and Programs: 1986

The Lacombe Research Station had 18 researchers working on:

- Red meats and beef production: 10
- Plant and soil science: 8

Two additional researchers were located at the Vegreville Research Substation.

research on factors influencing the growth of the animals, and on the resultant carcass and meat quality. Red meat research included work on the physical, chemical, microbiological, and sensory aspects of beef and pork quality from the producer's, processor's, and consumer's perspectives. Red meat research also focused on developing and evaluating new methods for improving beef and swine carcass-grading systems.

Vegreville Solonetzic Soil Substation

The Vegreville Substation was established in 1957 to investigate crop production problems on Solonetzic soils. These soils have a tough, hard pan 5 to 30 centimetres below the soil surface that restricts the movement of water and limits root penetration. Research took place in the eastern half of the province, using off-station sites, and focused on depth of tillage (plowing), crop rotations, and the use of commercial fertilizers. The outcome of this research, especially the work on tillage, was a significant increase in crop yield. In later years, the Substation focused on tillage, cropping systems, soil fertility requirements, and forage crop evaluation and management to optimize the productivity of Solonetzic, Luvisolic and Chernozemic soils. From 1984 to 1988, major renovations were undertaken that culminated in the construction of a new laboratory-office building in 1988. The facility closed in 1994 and staff members either retired or were transferred to the Lacombe Research Centre.

Plant and soil-science research focused on cropping practices, soil management, and weed control, primarily for barley, oats, and canola production in the central Alberta Parklands. Plant breeding research had moved away from regional horticulture crops such as tomatoes and apples and into oats and Hard Red Spring wheat. The Station was also responsible for conducting forage research, investigating its implications for beef production. In 1992, crops research was combined into a single operation consisting of laboratory and office space, and new greenhouse facilities and growth cabinets.

In 1993, the Lacombe Research Station was renamed the Lacombe Research Centre. As part of the national re-organization of Research Branch following the 1994 Program Review, the administration of the Beaverlodge Research Farm and its Fort Vermilion Research Field Site were transferred to Lacombe Research Centre, where they remain. These two sites allow researchers access to one of the largest non-cleared arable landmasses in Canada. With the inclusion of these two sites, Lacombe became the most northerly of the federal agriculture research centres.

The swine unit underwent several upgrades in the 1990s and early 2000s, becoming a biosecure and modern farrow-to-finish swine facility capable of handling up to 100 farrowing sows at one time. The beef unit was upgraded to a modern beef handling facility in the late 1990s, and a modern Growsafe™ feeding system was incorporated to enable monitoring of the feed intake of individual animals. This initiative demonstrates how the Centre, supported by Alberta Agriculture and Rural Development, has collaborated with industry and other government departments to create a world-class research facility for meat production. The Lacombe Research Centre now has a feedlot, swath grazing plots, and rangeland to handle upwards of 300 cow-calf pairs.

In 1998, a meat laboratory wing was added to the meat abattoir research unit. The addition provided for four large new meat laboratories that will support more extensive research into meat chemistry, biochemistry, sensory analysis, meat genomics, meat microbiology, and safety, as well as the impact of animal welfare on meat quality. In combination, these laboratories and the abattoir provide a unique facility in Canada that can allow researchers and industry to examine a greater range of input factors and their interactions on meat quality, safety and health, and nutrition.

Over the past 25 years, the abattoir and the expertise developed by the abattoir staff have allowed researchers to conduct studies on a wide range of alternate livestock species, such as emus, ostriches, bison, elk, deer, and musk ox. As well, new technologies such as hot-water carcass pasteurizers have been developed for use in this and other commercial abattoirs.

As the infrastructure for meat research expanded, the number of staff focusing on meat quality, meat lipids, meat safety and meat microbiology also increased. Beginning in the early 1990s, the Centre increased the number of its post-doctoral fellows and attracted a number of international visiting scientists from Spain, Inner Mongolia, and Brazil among others.

In the mid-1990s, the meat science group was instrumental in helping to modernize the beef carcass grading system implemented by the Canadian Beef Grading Agency. Several years later, researchers at Lacombe were granted a patent for a computer-assisted image analysis system that helped with the grading of beef carcasses. This system was licensed to a Canadian firm and used in North America until its recent replacement by a newer competing system.

In the early 1990s, parts of the crop and plant programs were either discontinued or transferred to other stations. The breeding of wheat and barley ended and the breeding of oats increased. During this period, an approach to integrated crop management research was also developed. Collaborative research between weed specialists, agronomists, and cereal pathologists located at Lacombe and entomologists located off-site led to the development of a research model that allowed a holistic research approach to studying multiple factors influencing crop production. Researchers increased the extent to which they conducted trials at multiple environmental sites across Western Canada, collaborating with other departmental researchers as well as researchers from universities and provincial institutions. The Department played a key role in the development of this model, being the only organization with testing sites in all western provinces and in a wide variety of environments.

The Alberta Department of Agriculture and Rural Development has been a key collaborator with the Lacombe Research Centre during the past 25 years. In the early 1990s, the first of these collaborations was manifested in the Alberta/Canada Barley Development Agreement, which brought together researchers from both governments to enhance barley development in Canada. Subsequent agreements were made with the province and industry partners, such as the Western Forage Beef Agreement, which helped foster development of the swath grazing practices that have enhanced the profitability of the cattle industry across Canada. Another example of cooperation is the multi-year agreement signed in 1998 with the Alberta

Canola Producers Commission to support agronomic and plant pathology research on canola at both Beaverlodge and Lacombe. This agreement has been extended for many years and has been expanded to include three additional centres in Western Canada. The resulting collaborative research has shown that simple and relatively inexpensive management practices can improve yields and help minimize production risks.

Livestock Genomics

In 2007, the Department established a collaborative relationship with the University of Alberta in support of bovine genomics, and subsequently, livestock genomics. The relationship allowed the co-location of two departmental researchers at the university facility, along with their equipment. This cooperation relieved the university of the expense of equipment acquisition, helped to create a critical mass of expertise, and gave departmental staff greater access to graduate students and the ability to expand research capabilities without the additional infrastructure costs.

To date, close to 90 percent of the research undertaken at Lacombe or Beaverlodge involves collaboration with external parties. It has enabled the leveraging of resources for both the Department and third parties, ensured the validity of the research, and helped accelerate the rate of adoption by industry.

Over the past 25 years, Beaverlodge and Lacombe have released 25 new cereal (barley, oat and spring wheat) and field crop (canola, favabean and yellow field pea) varieties, many of which are currently in use across Western Canada. Lacombe is one of the sites used in the co-op trials that take place across Western Canada, involving thousands of plots of cultivars, and varieties developed by other departmental and provincial and university programs.

People and Programs: 2011

The Lacombe Research Centre had 110 employees including 20 researchers working on:

- Integrated crop management systems: 4 (one at Beaverlodge)
- Pulse breeding: 1
- Meat quality: 4
- Meat microbiology: 5
- Environment/forage: 1
- Livestock genomics: 3 (two at the University of Alberta)
- Animal welfare: 1
- Apiculture: 1 (Beaverlodge)

Over the past decade, Research Branch has developed key priorities to enable more focused application of resources. All research projects are now subject to peer and internal review to ensure both research excellence and a focus on the key objectives and key priorities of the agricultural sector.

The Lacombe Research Centre has 800 hectares of land in Lacombe, 360 hectares in Beaverlodge and 190 hectares in Fort Vermilion. In addition to the internationally renowned crop research undertaken at Lacombe, the site is also known for its arboretum, established in 1908, which is recognized as a heritage tree site and is home to a number of historically significant trees that are unique to this region. The arboretum maintains a scenic walking trail used by many in the local community.

Research highlights over the past 25 years

Meat and beef production

- Developed and evaluated new procedures for swine and beef carcass grading
- Showed that hot-water pasteurization of beef and pork carcasses improves microbiological safety while saving money

- Developed an infrared image analysis system for taking thermal images of animals, allowing the early non-invasive detection of diseases in cattle, and more effective treatment
- Developed a computer vision system for augmenting the grading of beef carcasses
- Investigated the behaviour of food-borne pathogens under marginal growth or stress conditions
- Identified and characterized DNA markers or genes in beef cattle (using DNA marker association and gene expression analysis) for economically important traits, including fat deposition and composition, carcass merit, growth, and feed efficiency
- Validated gene or DNA marker-trait associations and the implementation of marker or gene-assisted selection in beef cattle genetic evaluation and breeding programs
- Quantified pathogens using combinations of molecular and conventional approaches
- Identified the factors that affect the various spoilage activities of bacteria that can grow on chilled meat
- Developed means of implementing hazard analysis critical control point systems at meat packing plants

Strategies for Northern and Parkland agriculture

- Developed practical integrated solutions for crop health and disease management, particularly in barley, oats, and canola
- Developed cropping systems for agronomic enhancement, weed management, conservation tillage and weed resistance to herbicides, particularly for the short-season environments in northwestern Canada

- Developed new technologies for seed production in grasses
- Improved the efficiency of forage-based beef production in the Prairie Parkland vegetation zone of Canada
- Developed sustainable cropping system platforms for biodiesel feedstock, and investigated their subsequent impact on quantity and quality

The Lacombe Research Centre, including the Beaverlodge Research Farm and its Fort Vermilion Substation, continues to conduct programs of integrated research, analyzing the meat value chain, integrated crop management systems and honey bee production in the Parkland and Northern regions. Many of the research projects are developed and conducted in collaboration with outside researchers in various disciplines from various national and international centres. Research in such areas as meat quality relies on support from researchers with expertise throughout the value chain (livestock genomics, livestock phenomics, meat quality, animal welfare, and animal production). Similarly, integrated crop management research involves pathologists, agronomists, and weed and soil researchers. Peer review and targeted funding ensure that the projects exhibit scientific excellence and speak to the priorities of both the industry sector and the Department.

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Beaverlodge Research Farm
Beaverlodge, Alberta

Rick Lawrence, Research Manager, Research Branch, Lacombe
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The Beaverlodge Experimental Station, established in 1917, and the Fort Vermilion Experimental Station, established in 1908, are in the unique position of being located on the edge of 15 million hectares of arable land. Research at Beaverlodge has been primarily dedicated to adapting and developing crops and crop management practices to the environment and soils of the vast region north of 53°N latitude. In addition, the Station has played a significant role within the Department as the sole existing site conducting research on honey bees ranging from breeding and management practices to pathology. Beaverlodge and Fort Vermilion continue to be integral locations with respect to the multi-site Western Canada crop- and crop management system trials, as well as supporting research and developing practices to meet the agricultural challenges of the future.

The early years, 1917–1985

The Beaverlodge Experimental Station was established in 1917 on a 16-hectare plot of land originally leased from William Donald Albright, who became the station superintendent and played a key role in initiating and developing agricultural research in the region.

Apicultural research began in 1922, and except for a hiatus between 1939 and 1953, has been a mainstay in the research programs at the Station ever since. Apiculture research has explored many aspects of breeding and management practice as well as pathology and its impact on the pollination of local crops. In 1954, the Station held its first beekeepers' field day, establishing a tradition that has been maintained up to the present, and giving producers and researchers the opportunity to exchange ideas and information on a regular basis.

Research at the Station initially responded to the many agricultural needs of the area, ranging from cereal and forage production to tillage, livestock, and horticulture. However, as priorities changed for the agricultural sector, so did the priorities of Research Branch and its establishments, which resulted in a more focused research strategy. In 1959, the Experimental Station was renamed the Beaverlodge Research Station. In 1965, it headed up the Northern Research Group of Agriculture Canada Research Facilities to explore agricultural potential in the North. This group was wound down in the 1980s.

Beaverlodge supported several breeding programs for horticultural crops such as apples, Saskatoon berries, strawberries and tomatoes, but also cereals, field crops, and forages, such as barley, canola, spring wheat, field peas, and alfalfa. By the 1950s, additional research programs had been implemented, including those examining soil management, plant pathology, forage breeding and production, and integrated weed management. Scientists at the Beaverlodge Research Centre were world renown for their development of management practices that improved acid soils.

The beginning of the second century of research, 1986–2011

During the mid-1980s, the Beaverlodge Research Station and the Fort Vermilion Substation studied plant breeding (barley, canola, and forage grass), agronomy, forages management, apiculture (management, diseases, and breeding), and soils and environment (nutrient cycling, microbiology, soil management, agro-meteorology, plant pathology, weed control, and winter hardiness). Being members of a small group with a limited scientific capacity, researchers were inclined to collaborate with others in their own field of expertise.

People and Programs: 1986

The Beaverlodge Research Station had 17 researchers working on:

- Cereal and oilseed crops: 2
- Environment and soils: 8
- Forage crops and apiculture: 7

There were two additional researchers located at the Fort Vermilion Experimental Farm.

Apiculture research has long been a core program at Beaverlodge; it stands as the only AAFC establishment that continues to support honey bee research, an essential undertaking considering the importance of honey bees in agriculture and the increased death rate among bees observed in recent years. Beaverlodge was instrumental in the production and release in 1988 of a new bee strain—the Alberta bee—that can produce 25 percent more honey.

Beaverlodge has also developed a number of new horticultural varieties over the past 25 years, in addition to accumulating knowledge to support the sector. Although the horticultural program had ended several years before, new varieties of apples, Saskatoon berries and strawberries were still under development and were released in the early to mid-1990s. The apple varieties were a result of research undertaken in collaboration with the University of Alberta and the University of Guelph.

In 1995, the Beaverlodge Research Station was renamed the Beaverlodge Research Farm, and Fort Vermilion became a Beaverlodge research field site. That same year, the Beaverlodge Research Farm and the Fort Vermilion Research Field Site were linked administratively with the Lacombe Research Centre. Following the 1994 Program Review, several Beaverlodge programs were reduced or relocated.

The facilities at Beaverlodge consisted of a collection of small, separate buildings that were added piecemeal as needs dictated. In 2000, a new building to house the crop research and greenhouse operations was constructed at Beaverlodge.

Collaboration with industry and industry associations has been fundamental to the success of research conducted at Beaverlodge over the past 25 years. In addition to providing financial support, it has helped to ensure the validity of programs, and has supported the adoption of resulting technologies.

Fort Vermilion

In 1908, an Experimental Station of 190 hectares was established in Fort Vermilion, 500 kilometres northeast of Beaverlodge. As at Beaverlodge, much of the research at Fort Vermilion was focused on supporting the agriculture of the northern portions of the Peace River Region, with emphasis on horticulture, home gardening, and crop evaluation. Fort Vermilion became an Experimental Farm in 1955 and was amalgamated with Beaverlodge in 1965.

In 1986, the Fort Vermilion Experimental Farm housed two researchers and was the Department's most northerly research site. Over the years, research has become much more focused; it is now concerned with crop research in collaboration with other research centres in Western Canada.

Although the last resident researcher moved from Fort Vermilion to Beaverlodge in 1994, many researchers from other western centres continue to manage parts of their programs at this northerly site. Today, it remains essential to the trials that are conducted across Western Canada, particularly those that assess the implications of shorter seasons and more northerly environments on crops and cropping systems. In addition, Fort Vermilion conducts research and helps support annual field days for local producers in collaboration with the local Mackenzie Applied Research Association. Research continues into crop evaluations, as well as into reduced tillage and fertilizer placement. Considering the large expanse of arable land that remains uncleared in the Northern Peace Region, the unique research at Fort Vermilion continues to provide value.

Several provincial government research positions were also co-located on-site, along with a number of support positions funded through programs such as the Farming for the Future program of the Alberta Research Council. In addition to hosting these externally funded research positions, Beaverlodge housed personnel supporting extension programs from both the public sector and from industry producer associations.

The three on-site programs focus on soils, canola, forages, seeds, insect pest management, and apiculture. In addition, Beaverlodge still manages four programs through off-site researchers located in Saskatoon, Winnipeg, Lethbridge and Lacombe, allowing it to maintain its presence in wheat and canola research, soil microbiology, and integrated crop management research. Finally, Beaverlodge is one of a number of western sites where crop-trials research is conducted to assess varieties and crop management systems under differing soil and environmental conditions.

In 2010, the Department signed a Memorandum of Understanding with Grande Prairie Regional College that will help the two organizations work together to increase science capacity in the region. This model is based on partnerships for developing the innovative capacity of the region, and constitutes an early strategy for building superior science and technology development teams in order to increase the competitiveness of the region.

Research highlights over the past 25 years

- Released a new bee strain with an increased honey yield of approximately 25 percent, along with other beneficial traits
- Developed a new tool to identify honey bees with enhanced disease and mite resistance that contributes to the maintenance of healthy bee colonies and to the reduction of wintering losses
- Focused on understanding and managing diseases and pests such as Nosema disease and Varroa mite in bees; research on honey bee pathology has increased in importance worldwide with the increase in colony losses of the last several years

- Released barley varieties AC Stacey and AC Albright and two Canadian Utility spring wheat varieties, Wildcat and Bluesky
- Released the canola varieties AC Sunbeam and AC Sungold
- Released two new Saskatoon berry varieties in the late 1980s, and several strawberry and apple varieties in the early 1990s
- Developed a very successful nitrogen-fixing inoculant line, NRG-34, which was subsequently licensed for use in Western Canada in such products as N-Prove and Tag Team, with significant adoption by the industry
- Supported the forage seed program in the Peace Region, which continues to operate with significant collaborative support from the industry association and a provincial forage seed specialist
- Research at Fort Vermilion on zero tillage and field production changed the landscape of the Peace River Region in the late 1990s where the adoption of conservation tillage practices and field pea production were embraced by farmers

Being situated on the edge of 15 million hectares of land, Beaverlodge is perfectly positioned to develop and conduct research to meet the many challenges that agricultural production faces. Beaverlodge and Fort Vermilion continue to be integral locations in the multi-site Western Canada crop- and crop management system trials.

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Lethbridge Research Centre
Lethbridge, Alberta

Brian Freeze, Research Manager, Research Branch, Lethbridge

The Lethbridge Research Centre, originally known as the Lethbridge Experimental Station and then the Lethbridge Research Station after 1959, was established in 1906 with a mandate to help early settlers in the region meet the challenges of a short growing season, a lack of moisture, high winds, varying soils, and a lack of adapted crop varieties. The past 25 years have seen many changes at the Lethbridge Research Centre; nevertheless, the Centre has stayed true to its regional mandate to develop irrigated and dryland cropping and livestock systems suited to southern Alberta. In addition, it has evolved into a source of national and international expertise with respect to ruminant and beef cattle research, biological control of invasive weeds, biomass and bio-energy production from cereal crops, the impacts of crop and livestock production on greenhouse gas production and climate change, and the understanding and mitigation of the food safety and human health impacts of beef production. Today, the Centre maintains a production focus on crop and livestock systems, but with an increased emphasis on environmental sustainability, human and animal health, non-food industrial crops, and ecological and economic modeling.

The early years, 1906–1985

The Lethbridge Research Centre had its beginning in 1900 when the Canadian North West Irrigation Company, an organization that brought water to the dry plains of southern Alberta, made land available for a model farm in the area. In 1906, William Harmon Fairfield, then director of the Agricultural Experiment Station in Wyoming, became the first superintendent of the newly established Lethbridge Experimental Station, which was renamed the Lethbridge Research Station in 1959. His mandate was to help early settlers in the region meet the challenges of a short growing season, a lack of moisture, high winds, varying soils, and a lack of adapted crop varieties. The Station is located along the western border of the Brown and Dark Brown soil zones of the Prairies, where the climatic conditions are classified as semi-arid, with an average rainfall of about 355 millimetres per year.

During the Station's first 30 years, work was focused on irrigation research and on determining the ideal water application rates for avoiding soil salinity. The result was the development of about 610,000 hectares of irrigated farmland. Soil conservation became a priority in the 1920s and 1930s as drought produced huge clouds of soil drifting across the Prairies. Researchers investigated strip farming, alternating crop and fallow land to break the power of the wind. This research extended into the 1960s and 1970s with the development of conservation tillage methods that prescribed the use of chemicals to control weeds, and the direct seeding of uncultivated land to prevent wind and soil erosion.

The drought years made it apparent that many dryland areas were more suited to ranching than farming, which led to the establishment in 1927 of the 17,000-hectare Range Experiment Station at Onefour, near Manyberries. Onefour was the cradle of the animal-science research program at Lethbridge. It eventually became a research field-site of the Lethbridge Experimental Station.

Until the 1960s, Onefour research primarily involved evaluating various breeds of sheep and cattle, as well as grazing systems and stocking rates for the short-grass prairie region. From the 1960s to the 1980s, the work shifted to the evaluation of cattle crossbreeding systems to support the commercial cattle industry's interest in exotic cattle imports—mostly European breeds such as the Charolais, Simmental and Limousin. Lethbridge animal science research continued to expand as the cattle industry in southern Alberta shifted into intensive feedlot finishing of calves and yearlings in the 1970s and 1980s. As irrigated farming developed in the region, it became apparent that the highest value-per-acre return on irrigation was cattle finishing using available byproducts from the sugar beet industry and the barley grown for silage on irrigated land adjacent to feedlots. Lethbridge Experimental Station animal researchers introduced refinements into the cattle finishing system, such as the feeding of processed barley and barley silage in varying ratios to calves or yearlings for short periods of time (three to six months). The area south of Calgary now feeds close to one million head of cattle annually, and Alberta is responsible for producing approximately 40 percent of the Canadian total with respect to beef cattle, breeding cows and heifers.

The beginning of the second century of research, 1986–2011

In 1986, regional crop and livestock systems research was largely focused on increasing the yields or reducing the production costs of existing regional crops (spring wheat, winter wheat, soft white wheat, barley, potatoes, corn, sugar beets, and forages on rangeland) and livestock (beef and dairy cattle, and sheep). Research was conducted by teams, with a number of disciplines (breeding, genetics, pathology, entomology, agronomy, and microbiology) supporting each commodity program effort.

People and Programs: 1986

Science administration was organized along discipline lines, with 58 researchers organized into six research sections:

- Animal parasitology: 6
- Animal science: 11
- Crop entomology: 7
- Plant pathology: 5
- Plant science: 17
- Soil science: 12

In 1987, the six research sections were combined into three larger science units: livestock, soil and crop sciences. This structure remained in place through the late 1990s with the exception of a 1993 change in the name of the Soil Science Section to the Land Resources Section, and a shift in the management of the Kamloops Research Station (currently known as the Kamloops Research Farm) to Lethbridge. The shift led to the development of an integrated program addressing range management in diverse ecosystems.

A new computerized feed mill and a new controlled-environment livestock facility opened in 1986. The feed mill enabled preparation of experimental rations (for animal feeding trials) and feed mixes with special additives. The controlled-environment facility was designed with large indoor animal chambers for housing livestock under tightly controlled conditions of temperature and photoperiod in order to study the interaction of livestock with insect pests. A new sheep facility that housed up to 300 sheep was constructed in 1991 to support research on the economic and biological efficiency of ewes and lambs.

The 1980s and 1990s also saw continued research on conservation management practices, such as minimum tillage, that would prevent soil erosion. Plot studies were initiated at Lethbridge in 1990 to investigate the long-term effects of treating (simulated) erosion with organic amendments (manure, compost) in order to restore soil productivity.

With the transfer of the arthropod quarantine program for biological weed control from Regina to Lethbridge, plans were developed for a new biocontainment facility at Lethbridge.

In 1993, the Station was renamed the Lethbridge Research Centre. Following 1994 Program Review, the Centre was assigned the national mandate in beef research. The program was strengthened by the transfer of the ruminant technology program from the Centre for Food and Animal Research in Ottawa, which closed in 1997.

In addition, the research focus shifted during this period to a smaller set of programs and to commodities that had potential for growth or that were new to the area (e.g. beans, potatoes, and soft wheat). Research programs for vegetables, corn, barley, Hard Red Spring wheat, sheep and dairy cattle were discontinued and consolidated at other research centres. Entomology programs for black flies, mosquitoes, cutworms, forage crop pests, rangeland insects (grasshoppers), insect pollinators (bees), as well as pesticides, were discontinued, either because they existed elsewhere or because they had become less important. Irrigation programs associated with agronomy, aquatic weeds, engineering, and drainage engineering were also discontinued in favour of those of the Alberta Agriculture, Food and Rural Development Irrigation Division's program in Lethbridge. Despite closure of the sheep program in 1995, the sheep facility persisted, with the maintenance of a flock of 100 ewes in support of ruminant animal studies on reproduction, physiology, and nutrition. In the late 1990s, a 1,000-head feedlot facility was built, complete with a set of pens outfitted with an electronic feed bunk monitoring system designed by Growsafe™, which allowed the recording of individual animal intake information.

Long-Term Plots

Agriculture and Agri-Food Canada boasts a collection of historical soils, soil data, and heritage field-plot experiments preserved at research centres across Canada. The 100-year-old field plots at Lethbridge demonstrate a wide range of strategies and simulated conditions, including crop rotation (both irrigated and dryland), fertilizer use, tillage, simulated erosion, and re-vegetation with grasses. In Saskatchewan, the long-term plots in Swift Current, Scott and Indian Head simulate the major soil-climatic zones of Western Canada; these have been in existence for 20 to 100 years. In southwestern Ontario, a series of plots were established near the town of Woodslee in 1956 to show farmers the importance of crop rotation on heavy clay soils.

These tools help scientists study the long-term effects of agricultural production.

In response to increasing public environmental concern, the Centre strengthened research on strategies for mitigating the environmental impacts of large-scale beef cattle finishing—in particular, the concentration and use of feedlot manure. A composting program for feedlot manure was initiated in 1996; researchers have examined, among others, the effects of composting versus stockpiling on nutrient dynamics (carbon, nitrogen, and phosphorus) and greenhouse gas emissions, the dissipation of antibiotic residues during composting, and nutrient runoff characteristics from compost windrows. Several other long-term studies (long-term manure plots: composting versus fresh application) were started in 1998 to compare the effect on soil, water, crops, and air of the land-application of fresh and composted cattle manure with straw or wood bedding. Ancillary research was initiated on crop yields and nutrient uptake by barley under these treatments, the leaching of nitrogen, phosphorus, and soluble salts, and soil denitrification, or nitrous oxide (N_2O) emissions.

In 2000, a new long-term cropping systems study was initiated at the Vauxhall Substation to focus on irrigated land, a very important part of the economy of southern Alberta, where cropping practices are more intense and diverse (e.g. potatoes, sugar beets, beans, and timothy) but return little crop residue to the land to replenish soil organic matter and reduce erosion risk. The 12-year study examined the use of compost as a replacement for fertilizer nutrients, as well as direct seeding, fall-seeded cover crops, and solid-seeded narrow-row beans (i.e., sustainable practices) for rotations of three to six years.

With the implementation of a new Agricultural Policy Framework, Research Branch developed four national research programs, beginning in 2002. To align with these national programs, the Lethbridge Research Centre sections were reorganized in April 2002 into three new ones: environmental health, sustainable production systems, and bioproducts and bioprocesses. In 2003, the Research Manager position was created to oversee the Centre's operations.

Research Farms

In addition to its principal location, the Centre operates three Research Farms: one at Onefour, where studies on livestock and range management are conducted; one at Stavely, to study the management of foothills rangeland; and one at Vauxhall, for irrigated crop production and drainage studies. All three Research Farms are located within Alberta.

In 2003, a major 4,600-square-metre addition to the Lethbridge Research Centre was completed, that featured a new insect microbial containment facility, new laboratory facilities, insect-rearing facilities, a food quality laboratory, office space, and new greenhouses. The addition replaced older facilities in the biology building and food-processing laboratory, which were demolished. Much of the previous greenhouse complex was replaced by modern greenhouses with better controls and more efficient layouts.

Opened in 2004, the 883-square-metre insect containment facility is equipped for the containment of arthropods and insect and plant pathogens. The facility's main function is to provide a secure environment in which researchers can study the biology, efficacy, and specificity of arthropods and pathogens for use as biological control agents. Biological control is becoming an increasingly important tool in the management of agricultural pests. It is hoped that the Lethbridge containment facility will play a vital role in the development of new, effective and environmentally-friendly control agents.

In 2009, the Lethbridge and Eastern Canada potato research programs were merged into a new national breeding program based at the Potato Research Centre in Fredericton. There, the national potato breeder continues to develop and evaluate new germplasm for Alberta growing conditions, and directs supporting research at Lethbridge in breeding, tissue culture, disease screening, molecular analysis, laboratory testing, and field trials.

During the past decade, beef research has focused on pre-slaughter production issues related to feed efficiency, food safety, environment, genetics and genomics, rumen genomics, pest management, animal welfare, and reproduction.

Over the same period, field crop and forage research has contributed significantly to the development of the potato, bean, wheat, and ethanol industries of Western Canada through breeding, improved agronomic practices and plant disease control methods (e.g. biological control agents). Research on forages has focused on the development of germplasm and cultivars with improved productivity, nutritive value, persistence, novel uses, and stress tolerance.

Research on environmental sustainability has focused on understanding the long-term impacts of crop and livestock production systems on land, air, and water, and on biodiversity and climate change.

Research highlights over the past 25 years

Feed efficiency

- Revised concepts on effective fibre in order to support the development of a rumen health system to mitigate and better understand sub-acute acidosis in fibre digestion
- Demonstrated that lowering dietary crude protein was a practical and cost effective way of reducing ammonia emissions from feedlots

Pest and disease vectors

- Elucidated the control of beef pests (stable fly, horn fly, ticks, and lice), the role of pests (midge and ticks) as animal-disease vectors, and the environmental impacts of chemical pest control
- Refined the understanding of the development, diapause, and overwintering of horn fly
- Held field studies on the vectorial capacity of native midge populations for bluetongue that resulted in significant changes to Canada's beef import policies
- Identified species of wasps parasitic to the pest flies that affect cattle, which resulted in the their commercialization as biological control agents

Beef cattle reproductive physiology

- Demonstrated that feeding high-energy diets to beef bulls after weaning was deleterious to semen quality and sperm production, whereas roughage-based diets enabled selection of bulls with the fastest rate of gain, while concurrently preserving their fertility potential
- Determined that synchronization of estrus and ovulation in-house enables fixed-time artificial insemination without the need for estrus detection

Beef cattle genetics

- Added to current genetic evaluation tools by developing testing- and selection procedures for feed efficiency, defined as estimated breeding values or expected progeny differences; these are used in the beef industry to provide accurate estimates of the genetic merit of animals with respect to economically relevant traits such as fertility, growth rate, lean yield, maternal productivity, calving ease, and feed efficiency

Field crops and forages

- Developed, in cooperation with Morden Research Centre, early maturing bean cultivars (including Pinto, Navy, Great Northern, Small Red, Black, and Pink dry beans) exhibiting a more upright growth habit that limits white mold damage and allows for the option of direct harvesting from narrow-row planting; more than 80 percent of bean varieties grown in southern Alberta were developed at Lethbridge and Morden
- Made available to members of the Western Potato Consortium several potato selections, which resulted in the registration of 12 cultivars
- Developed somatic potato hybrids with resistance to late blight and Colorado potato beetle, using wild potato germplasm from Mexican species
- Developed and released winter wheat varieties for Western Canada
    - AC Readymade and AC Tempest, with high protein content and strong straw, particularly suited for southern Alberta
    - AC Bellatrix and Radiant, with good straw, disease resistance and winter survival
    - Broadview, suited to ethanol and livestock production
    - Flourish, with combined resistance to stem rust, leaf rust and common bunt, and with strong straw, early maturity and excellent quality

- Developed and released two high-yielding alfalfa cultivars with high levels of resistance to bacterial wilt and verticillium wilt; developed Tristar fenugreek for intensive production of silage and hay for the dry, warm summers of Western Canada

Environment

- Studied the impact of adding fresh and composted cattle manure from beef feedlots to cropland in southern Alberta; as a result, the application of composted manure has increased
- Recommended winter grazing of rough fescue in native grasslands, as opposed to summer grazing, to conserve the grasslands while reducing the cost of livestock production
- Developed whole-farm modeling software (HOLOS) that estimates greenhouse gas emissions, based on information entered for individual farms
- Revised production practices, based on long-term crop plots that showed the environmental impact of crop and livestock systems

Biological of weeds and insect pests

- Released several arthropods for the suppression of more than 20 introduced invasive plant species
- Made several successful releases since 2001 of two weevils, *Mogulones cruciger* (root feeder) and *Mecinus janthinus* (stem borer), and *Aphthona* beetles, to control houndstongue, Dalmation toadflax and leafy spurge
- Established two new biological control agents for Russian knapweed in southern Alberta in 2010

Scientific achievements by the Lethbridge Research Centre over the past 25 years have responded to production challenges faced by farmers, and to opportunities to advance and change the industry. New facilities have strengthened and supported the Centre's national mandate for beef and ruminant research, regional crop genetic-enhancement programs and new endeavours, such as the biological control of invasive weeds and pests. The resulting achievements have helped make the agriculture sector more innovative, competitive, and sustainable.

Currently, the Lethbridge Research Centre, with its 51 researchers, maintains a regional focus on crop and livestock systems unique to southern Alberta, with its varied soils, irrigation, high winds and relatively high temperatures. New molecular and genomics tools will greatly influence crop and livestock breeding and selection technologies. Increased emphasis on environmental sustainability, human- and animal-health impacts, non-food industrial crops, synergies with adjacent industries, and ecological and economic modeling will enlarge the scope of impacts and require more multi-disciplinary and multi-institutional approaches and partnering.

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Pacific Agri-Food Research Centre
Summerland, British Columbia

Frank Kappel and Gerry Neilsen, Research Scientists, Research Branch, Summerland

Summerland Experimental Station was established in 1914 with a mandate to undertake research to help solve the problems of a developing agricultural industry. Early research focused on a wide range of crops, including apple and cherry, poultry, swine, and cattle. The Experimental Station was renamed the Summerland Research Station in 1959. The year 1986 brought a new beginning to the Research Station with the completion and occupation of a new office-laboratory building and its attached greenhouse. This facility made it possible to focus on improving tree fruit production and tree fruit crop utilization. In 1996, the Pacific Agri-Food Research Centre was formed, consisting of two establishments, one located at Summerland and the other at Agassiz. Current areas of research include research into growing healthier crops, innovative solutions for health and wellness, insect and disease control, and new and improved safety and quality for food products.

The early years, 1914–1985

Summerland Experimental Station was established in 1914 with a mandate to undertake research to help solve the problems of a developing agricultural industry. All aspects of farming were studied, with emphasis on determining which crops, crop varieties and breeds of livestock were suited to the arid production region of the British Columbia Interior. Research was also conducted at Kelowna, established in 1931, and at Creston, established in 1940. Creston reported to Summerland Experimental Station beginning in 1951. The Station's research scope was narrowed over the years as the variety of crops grown in the region decreased, focusing more on the improvement of tree fruit production and tree fruit crop utilization. In 1959, the Experimental Station was renamed the Summerland Research Station.

Accomplishments from 1914 to 1986 included: the development and release of the Spartan apple and the Van sweet cherry; the identification of nutrition deficiency problems in tree fruit, including deficiencies of boron, zinc and magnesium; successful feasibility trials for the control of codling moth by the release of sterile male moths; identification of apple mealybug as the carrier of little cherry virus; determination of irrigation requirements for tree fruits and grapes; recommendations for the control of bloat in cattle grazing alfalfa; the development of processes for making clear and opalescent apple juices, pie fillings, sparkling cider, brined cherries, and glace cherries; and the designing of vacuum equipment for apple segments used in pie filling.

The beginning of the second century of research, 1986–2011

The year 1986 brought a new beginning to the Summerland Research Station with the completion and occupation of a new 12,036-square-metre office-laboratory building that brought all the researchers together under one roof. The building included an attached greenhouse, transmission and scanning electron microscopes, a food-processing pilot plant area and a phytotron with 90 controlled-environment rooms.

Along with the modern laboratory facility, Summerland Research Station has 320 hectares of land, of which 90 hectares can be irrigated and are suitable for fieldwork with an emphasis on tree fruit and viticulture. Irrigation is vital to the success of the work at Summerland, since the Station is in the arid British Columbia Interior where the average annual precipitation is 279 millimetres.

In late 1980s, the research was divided into four programs: entomology-plant pathology; food processing; pomology and viticulture; and soil science and agricultural engineering. There were 23 researchers conducting research in the following areas:

- Fruit trees, notably apple, pear and cherry, with special emphasis on virus and fungus diseases, insect pests (such as mites, San Jose scale, and codling moth), breeding, weed control and storage;
- Grape management and enology;
- Soil chemistry, fertility, and management;
- Agricultural equipment development and assessment; and
- Food technology and chemistry.

The organizational structure and research were fairly stable from 1986 to 1992, with no changes to the programs, and the number of researchers ranging from 23 to 25.

Between 1992 and 1995, environmental studies, food research, and horticulture studies remained fairly constant. The research work at Kelowna and Creston ceased at this time. The Station was renamed the Summerland Research Centre in 1993.

Pacific Agri-Food Research Centre

The Pacific Agri-Food Research Centre, created in 1996, consists of two research establishments, one located at Summerland and the other at Agassiz. The Centre also includes the Kamloops Research Farm, which reports to Summerland; and the Abbotsford Research Field Site, the British Columbia Land Resource Unit and the Yukon Land Resource Unit, all three of which report to Agassiz.

Following the 1994 Program Review, a number of research programs at Summerland were phased out, including those focused on irrigation engineering, vegetation management, viticulture study, plant water relations, storage physiology, analytical chemistry, soil-borne diseases, pomology, plant physiology, and growth regulators. When the Pacific

Agriculture Research Centre in Vancouver closed in 1996, many of its staff were transferred to Summerland to conduct plant virus research. To accommodate the increase in staff numbers, major renovations were undertaken to modify and expand the Centre's laboratory space.

At that time, there were 32 researchers working in three program areas: food research, horticulture and environment, and biotechnology-molecular biology. In 1996-1997, the Agri-Food R&D Matching Investment Initiative (MII) funding program was initiated to involve industry in research by having them invest funds which were subsequently matched by the Department match them. The viticulture program was re-instated in Summerland in 2000.

The Minor Use Pesticides Program launched in 2002 began to conduct field and greenhouse trials to collect efficacy and residue data for submission to the Pest Management Regulatory Agency for new product registration.

The MII program was followed by the Developing Innovative Agri-Products (DIAP) program, which supports industry-led science and technology projects.

People and Programs: 2011

Summerland comprises 320 hectares, with approximately 90 hectares irrigated and available for research. It employs 25 researchers and has a range of facilities including:

- Food research pilot plant
- Sensory and quality evaluation laboratory
- Extraction and fractionation laboratory pilot plant
- Electron and confocal microscopes
- Inorganic and organic analyses laboratories
- Ornamental gardens and museum
- Field drainage lysimeter

Current areas of research include the following.

- Healthier-crops research, with emphasis on overcoming soil and water contamination, which limits plant growth; on collecting efficacy and residue data for minor use products; on developing apple and sweet cherry varieties with improved quality and disease resistance; on discovering ways to enhance the quality of tree fruits and specialty crops and to produce them in an environmentally sustainable manner; and on determining the impact of disease-causing fungi and bacteria on plant health.
- Innovative solutions for health and wellness, with emphasis on developing foods from components of Canadian crops and byproducts from food industries that promote health beyond their basic nutrients; on investigating food ingredients to determine antioxidant and anti-inflammatory properties; and on evaluating fruit and vegetable products for taste, texture, appearance, and smell.
- Pest and disease control, with emphasis on understanding how plant viruses work and on developing better diagnostic methods and control strategies; on studying the effectiveness of baculoviruses for possible use as biological control agents; on maintaining the Canadian Plant Virus Collection; on understanding the effects of disease-bearing insects and microbes on fresh fruit and vegetables; and on collecting efficacy and residue data for minor-use product registration for insects, diseases, and weeds.
- Improved safety and quality for food products, with emphasis on assessing the quality of fruits and vegetables following the development of preservation techniques to prolong their freshness; on determining factors affecting the shelf life and quality of fruit and vegetable products destined for fresh consumption, on improving Canadian wines through viticulture techniques (deficit irrigation, crop load management and crop management), and profiling their characters; and developing new separation techniques to obtain components from crops that can be converted and processed into higher-value end products.

- Quality (high-value) crops in a healthy environment, with emphasis on conserving water and nutrients; on water-resource modeling and maintenance of soil quality; on developing apple and sweet cherry varieties with improved quality and disease resistance; on discovering ways to enhance the quality and reduce the variability of tree fruits, grapes and other specialty crops and their production; and on reducing the impact of pesticides by discovering alternative pest and disease management systems.

Research highlights over the past 25 years

- Showed that pheromone disruption reduces populations of codling moth to well below the level necessary to initiate and maintain the Sterile Insect Release program
- Showed that sterile insect release and area-wide control reduces pesticide use, controls codling moth in apple and pear orchards, and enables new insect biological control options in British Columbia
- Demonstrated that the natural plant hormone gibberellic acid effectively improved the fruit size and firmness of late-maturing sweet cherry cultivars and slowed fruit ripening, thus extending the marketing season
- Found that application of fertilizers to fruit trees through trickle irrigation systems allowed nitrogen rates to be reduced to as low as 25 percent of the broadcast rate without affecting growth, nutrient uptake, or yield
- Developed a rapid method for complete chemical characterization of anthocyanins
- Released the late-ripening sweet cherry varieties Lapins, Sweetheart, Staccato and Sentennial, which have allowed British Columbia growers to capture the high-quality and high-priced cherry market in Asia and Europe, initiating a renaissance in the sweet cherry industry

- Contributed to the development of modern high-density apple production in British Columbia through research on fertigation, drip irrigation, micro-sprinklers, rootstock evaluation, and orchard vegetation management
- Released new apple cultivars, such as Silken, Aurora Golden Gala, and Nicola, among others, which are high quality apples destined for various markets in Canada
- Developed molecular tools to help identify and control plant viruses such as little cherry disease, allowing the sweet cherry industry to re-establish itself in the Creston Valley after having been devastated by the disease
- Played a key role in developing a very sensitive, rapid and specific diagnostic test for plum pox virus, which is being used throughout North America
- Developed strategies to control insect pests using baculovirus pathogens; baculovirus-derived genetic elements were also incorporated into commercial systems that allow researchers to produce proteins for research or commercial purposes in insect tissue-culture cells
- Generated greater knowledge of the molecular genetics of the wheat leaf rust and small grain-infecting smut fungi
- Developed DNA arrays for the detection of apple mildew and scab
- Identified factors that contribute to grape berry shrivel; studied the effects of interactions between deficit irrigation, vine balance and leaf-removal timing on vine physiology and fruit quality; developed key flavour and aroma volatiles in Okanagan Merlot and Cabernet Sauvignon; explored the management of grape sour rot, and of grape pests, and the nutritional requirements for maintenance of healthy vines and the highest-quality grapes
- Helped the British Columbia grape industry, through sensory research, to design and implement a wine quality-assurance program and to develop the Vintners Quality Alliance standards

- Determined crop water requirements under climate change scenarios for three time intervals (2010-2039, 2040-2069 and 2070-2099) and compared the predicted demand with current water use and water supply; these water-demand models have been incorporated into regional water and supply models and are in use for the Okanagan and other watersheds throughout southern British Columbia
- Identified components, beyond basic nutrients, of Canadian crops such as prairie carnations, flax, sea buckthorn, wild berries, and small fruits, to use in the development of foods that promote health
- Developed innovative processing strategies for fresh-cut fruit and vegetable products, including modified processing schemes and the application of plant compounds with antimicrobial activity

Over the past 25 years, Pacific Agri-Food Research Centre at Summerland has successfully adjusted to all changes in the organizational structure and the movement of programs and researchers, and has continued to generate new knowledge and to innovate. Current areas of endeavour include: research for healthier crops; innovative solutions for health, wellness, and environmental sustainability; pest and disease control; and new and improved safety and quality for food products.

Pacific Agri-Food Research Centre
Agassiz, British Columbia

Victoria Brookes, Research Scientist, Research Branch, Agassiz

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One of the five original experimental farms created in 1886 is located in Agassiz. Significant contributions were made in Agassiz over the years to plant and animal management and production. New cultivars from the berry and forage breeding programs have been developed and used locally and worldwide. Developments in integrated pest management have expanded the options for pest control using pheromones, biological agents and reduced-risk pesticides. Greenhouse production and pest control methods have been improved. Systems have been developed for managing forages and reducing the environmental impact associated with intensive livestock production in a high rainfall environment. Forage production has increased, and manure management is being carried out with better environmental practices. The genetic diversity of poultry has been preserved, and cooperative research with the University of British Columbia has increased knowledge of animal welfare in dairy production systems. These advances were facilitated by the construction of modern compost facilities, a new laboratory and office complex in 2001, and several new animal husbandry buildings.

The early years, 1886–1985

Agassiz, British Columbia is the location of one of the five original experimental farms that were created in 1886. Many varieties of fruit trees were planted, and by 1900 it was known for its vast collection of plants, with more than 3,000 varieties being tested.

Wheat breeding carried out at Agassiz—crossing the famous late-maturing variety Red Fife with the early Indian variety Hard Red Calcutta—resulted in the variety Markham, which was used in the breeding of the variety Marquis, which became a core industry cultivar. From 1911 to 1925, horticulture activities were concerned mainly with variety and cultural experiments on vegetables and bush fruit. Horticulture research was expanded beginning in 1925, and raspberry research was intensified as the existing variety went into decline.

From 1936 to 1947, forage-crop experimentation advanced the use of grasses and clovers for pasture and hay. During this period, a researcher from Agassiz supervised the seeding of all airports in the Western Air Command of the Royal Canadian Air Force. A plant introduction nursery was established, and active plant breeding work began with perennial ryegrass and orchardgrass.

In 1950, the first use-patterns for herbicides in strawberries were released and used by the local industry, as well as by producers in Washington State and Oregon. Also in the 1950s, a broccoli breeding program was initiated, and resulted in the development of some of the first single-headed varieties. In 1959, the Experimental Farm was renamed the Agassiz Research Station. In 1962, the first report was published on the effect of specific latent viruses on the vigour, yield and quality of strawberries. This research resulted in the establishment of a virus-free strawberry plant production program for British Columbia.

In the 1970s, emphasis was placed on producing out-of-season vegetables. Studies showed that higher yields and earlier harvests are possible by using over-wintering techniques and protective covers. In the late 1970s, the first vegetable postharvest physiology and storage research program was initiated in response to the need for interpretation and implementation of vegetable storage information developed in other parts of the world.

The purebred Holstein herd, established in 1911, was the source of high-quality breeding stock and demonstrated optimum management and feeding practices.

People and Programs: 1986

There were 54 employees at the Agassiz Research Station, including 12 researchers working on:

- Dairy cattle: 2
- Poultry: 3
- Weed control: 2
- Turf: 1
- Vegetable crops: 2
- Soils: 2

There were several buildings, including renovated horse barns, being used for the office, laboratory, and work areas.

The beginning of the second century of research, 1986–2011

In 1986, dairy research was focusing on dairy cattle nutrition, including studies of ruminant mineral biochemistry and of silage additive. In 1998, the University of British Columbia (UBC) Dairy Education and Research Centre was established. As UBC took over the operation of the dairy program the Department worked in collaboration with it to advance the well-being and productivity of confined dairy cattle. Several dairy research facilities were added to the Centre. Dairy researchers examined stress factors, calf-feeding management and cow and calf behaviour. Measurements of cow and calf comfort are used to help design environments that eliminate long-term stress and improve the health and welfare of dairy cattle. Current projects include improved methods of detecting lameness in cows, behavioural changes associated with illness in calves, methods of calf-rearing used by Canadian producers, the effects of flooring on cattle locomotion, and the welfare implications of automated milking systems.

Poultry research focused on a number of issues, notably the role of minerals in the diet on sudden death syndrome and stress. Boron was found to have an effect on eggshell quality. Research on poultry behaviour and welfare improved the well-being of commercial poultry. Research in the 1990s increased feed conversion so that industry was able to produce healthier chickens through more efficient feed use. Research also demonstrated the benefits of supplementing poultry diets with enzymes. Avian genetics research conducted in collaboration with experts from the United Arab Emirates, the University of British Columbia and the U.S. Department of Agriculture's National Animal Genetic Program resulted in the development of gonadal cryopreservation and transplantation for the conservation of avian genetic resources. Work on the molecular ecology of food-borne bacteria in poultry represents a unique dimension of the Department's overall research. The scope of research has expanded to include investigation of the bacterial community, management of litter and the spread of bioaerosol bacteria from poultry.

The Soil and Environmental Protection Section, established in 1992, is developing novel and innovative technologies to reduce the environmental impact of intensive farming carried out in close proximity to a large urban population in a pollution-prone high-rainfall environment. The soil biochemistry/fertility research program, which had begun in 1978, has improved nutrient use for sustainable and economic production of numerous high-value crops, ranging from nuts to berries to field vegetables. Now that the environmental implications of excessive nutrient application becoming more apparent, focus has shifted to ensuring maximum crop production while minimizing pollution of soil, water (surface and ground), and atmosphere, and to mitigating global warming. The work has generated: four crop varieties; a patent for enhancing the antioxidant and nutrient selenium in food and feed crops; a novel manure applicator marketed across North America; a corn cropping system designed to reduce leaching that is a recognized best management practice in British Columbia, Washington and Oregon; and several unlicensed technologies enabling farmers to recycle farm nutrients and other inputs. Work quantifying and reducing the escape of ammonia into the atmosphere has national and international environmental impact.

The Soils and Environmental Protection team worked to reduce the impact of agricultural production on soil quality. Winter cover crops that limit the number of days that bare soil is vulnerable to erosion can be cultivated in the spring, providing added nitrogen and organic matter. Investigations of the use of compost for mulches and as a fertilizer source, of the impact of organic amendments and mulches, and of the effect of alternative water and nitrogen management practices on root diseases of perennial fruit crops are all in progress. Other new research projects include a study of the benefits of composts and compost teas in the control of plant pathogens, and a study of increased food quality through antioxidant enhancement of greenhouse-grown vegetable crops. A seamless soil-map data set for the Lower Fraser Valley and Okanagan Valley, as well as Upland map sheets, and a joint soil-sampling project have been completed in coordination with producer groups and the British Columbia Ministry of Agriculture.

Crop science research has expanded from field to greenhouse in the wake of significant expansion of greenhouse production in the Fraser Valley. In the 1990s, greenhouse research was generously supported by industry, which resulted in the construction of a research greenhouse and the provision of research funds. The greenhouse work expanded to examine the postharvest quality and shelf life of tomatoes, cucumbers, peppers and lettuce.

From 1979 to 1995, vegetable postharvest research was undertaken, including work on non-destructive methods for measuring freshness prior to any obvious visible signs. This work confirmed the importance of cultivar selection to postharvest quality.

Methods of weed control expanded—from cultivation and the use of herbicides to investigating the beneficial allelopathic effects of various ground covers for crop production and weed control. This research supported the use of various ground covers and has helped growers with improved soil health as well as weed control.

Research on integrated production systems has resulted in recommendations for using the waste from tank-raised farmed fish to produce wasabi (Japanese horseradish) without the need for additional fertilizers. Raising fish in tanks avoids any issues with ocean-based fish farms.

In 1994, a program to register pesticides for small area crops was initiated at Agassiz. This was expanded into the national Minor Use Pesticides Program in 2002. Agassiz is conducting pesticides evaluations to collect efficacy and residue data for many field and greenhouse crops. These data form the basis for supporting or rejecting the registration of pesticides.

By the late 1990s, Agassiz had become a world leader in wireworm and cabbage-maggot research. Several new species of wireworm in Canada have been identified; it was discovered that their susceptibility to insecticides varies widely. The positive effect of beneficial beetles in berry crops has been confirmed. Current biological control research is focused on a new aphid biological control as well as the classical biological control of pests of canola and crucifer crops, namely cabbage seed pod weevil, swede midge, cabbage root maggot, and diamond back moth. Aphids have been established as carriers of the new damaging blueberry disease, scorch virus. The work has set thresholds and guidelines for aphid control in blueberries. Collaborative research between Agassiz researchers and taxonomists at the Eastern Cereal and Oilseed Research Centre in Ottawa showed that leafrollers on raspberries in the Fraser Valley are attacked by 14 species of parasitoids.

In 1993, the Agassiz Research Station was renamed the Agassiz Research Centre. In 1994, the Agassiz and Vancouver centres were linked to form the Pacific Agriculture Research Centre until the Vancouver Centre closed in 1996, at which point the Agassiz and Summerland centres were linked to form the Pacific Agri-Food Research Centre. The two sites became two separately managed centres in 2008.

People and Programs: 2011

Agassiz had 14 researchers working in two main programs:

- Environmental health: 6
- Sustainable production systems: 8

The Agassiz location covers 310 hectares, with a field site in Abbotsford covering 7.5 hectares. In addition, the British Columbia Land Resource Unit and the Yukon Land Resource Unit report to Agassiz.

The new Agassiz office and laboratory complex was opened in 2001. Research activities on soil, water and air quality, integrated pest management, crop genetic enhancement, and crop and livestock production systems were finally combined under one roof. The complex has a level-2 microbial containment laboratory.

Since 2002, Agassiz has focused on two main programs. The environmental health program is managed under two sections: soil, water, and air quality; and integrated pest management. The sustainable production systems program is managed under three sections: crop genetic enhancement, crop production systems, and livestock production systems.

The Centre is located on the main town road in Agassiz. Its beautiful arboretum and grounds are a popular public destination. Agassiz is well known for its annual fall fair and corn festival, which attracts many people. The Centre is the original location of the popular Circle Farm Tour, which was set up to promote agricultural produce in the area.

Research highlights over the past 25 years

- Determined parameters for sudden death syndrome (SDS) in poultry, and the effect of minerals in the diet on SDS and stress
- Developed gonadal cryopreservation and transplantation for the conservation of avian genetic resources

- Developed a post-harvest nitrate test for raspberries and a pre-side-dress soil nitrate test for corn to facilitate the reduction of nitrate contamination, particularly in the Abbotsford aquifer and other corn growing areas
- Carried out research with a number of partners on pheromone-based mating disruption of blackheaded fireworm (*Rhopobota naevana*); the research was instrumental in the attainment of registration of the pheromone for use on cranberries in Canada and the U.S.—the first registration of a sprayable pheromone on a food crop in Canada
- Developed an improved nutrient-recirculation technology specifically for greenhouse rose production
- Prolonged the shelf life of greenhouse cucumber and peppers by opening the canopy to increase the amount of sunlight reaching the cucumber surface, and by storing peppers at 7° C instead of 10° C
- Ensured good tomato flavour by harvesting tomatoes at the pink-to-light-red stage, and keeping them at room temperature
- Developed several new biological controls for spider mites (*Feltiella acarisuga*), thrips (*Hypoaspis gillespii*) and greenhouse whitefly (*Dicyphus hesperus*) for the greenhouse industry
- Demonstrated that the method of compost preparation (mesophilic or thermophilic) influences the disease suppression properties of the compost, and that compost can suppress pathogens such as Fusarium and gummy stem blight
- Identified several new types of wireworm and found that there is great variability in their susceptibility to insecticides
- Demonstrated the efficacy of barrier fences in reducing the detrimental effects of cabbage maggots on crops, thereby reducing the need to rely on pesticides
- Released four kiwi varieties that mature three to four weeks earlier, and contain twice the vitamin C of the standard Hayward, making it possible to grow kiwi in new areas of Canada

- Released a new raspberry variety (Chemainus) that quickly predominated in the fields of British Columbia and the U.S. Pacific Northwest
- Discovered a unique strain of the insect pathogenic fungus *Metarhizium anisopliae* near Agassiz, which has proven to be the most virulent isolate of its kind in the world

South coastal British Columbia has become an important national region for the intensive production of dairy, poultry, and high-value horticultural crops, and for environmental research. There is a rapidly growing demand for fresh produce with high nutritional and aesthetic qualities that is produced locally using environmentally and ethically responsible methods. Over the past 25 years, Agassiz has made major contributions to plant and animal management and production.

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Kamloops Research Farm
Kamloops, British Columbia

Klaas Broersma, Research Scientist, Research Branch, Kamloops

The Kamloops Experimental Station, a substation of the federal experimental station at Manyberries, Alberta, initiated research in 1935 in south-central British Columbia in response to requests from the ranching industry. After carrying out a number of useful research projects, the facility was closed in 1940, due to the onset of the Second World War, and then re-opened in 1947. In the 1980s, research was conducted in the disciplines of range ecology, range management, plant physiology, alfalfa bloat, poisonous plants, soil management and fertility, agronomy, beef cattle nutrition, and feedlot studies. The Station began to report to Summerland in 1995.

The early years, 1935–1985

The beef cattle industry in Canada began to develop when the first ranchers settled in the southern interior of British Columbia in the early 1860s in the wake of the Cariboo Gold Rush. Investigation of Canadian rangelands began in Manyberries in the southeastern corner of Alberta in 1928.

The Kamloops Experimental Station, a substation of the federal experimental station at Manyberries, initiated research in 1935 in south-central British Columbia in response to requests from the ranching industry. A number of studies were conducted at that time to identify plants and their characteristics, classify vegetation and soil types, salt use, range condition, grazing capacity, cattle weight gains and weed control, and to introduce grass species, crop production, water development and other aspects of range management. After this promising start, Kamloops was closed in 1940, due to the onset of the Second World War. Former staff members made trips to British Columbia each summer to continue some of the range studies. Some enclosures that were established to study the impact of grazing on vegetation and soil are still in use today, and continue to provide range plant succession information.

The research program was re-established in 1947 with the goal of investigating range management in the interior valleys of British Columbia and the Cariboo Plateau, and of researching ways to increase the efficiency of range livestock production that were consistent with range conservation and re-vegetation. At the same time, permanent facilities were established on the current site, which in spite of various name changes, is still best known as the Kamloops Range Research Station (renamed as such in 1962). A regional office of the Engineering Branch of the Prairie Farm Rehabilitation Administration was established in the Kamloops Range Research facility after the Second World War and remained there until 1957.

The main site, located on 57 hectares of irrigated land in North Kamloops, included offices, a laboratory, a barn and other buildings, as well as a feedlot and field plots. The Prince George Experimental Farm reported to Kamloops after 1979.

Because the Kamloops Range Research Station had little rangeland under its direct control, an agreement was reached with the Tranquille Livestock Association to use its range and livestock for scientific studies under existing ranching conditions. A 500-hectare range field station was established at Pass Lake about 30 kilometres north in the forested rangelands. The research facility at one time also included the Entomology Laboratory and eight illustration stations, farms, or ranches used to demonstrate cooperative research. The facilities and programs were developed over time in support of the beef cattle industry and other agriculture in the British Columbia Interior.

The beginning of the second century of research, 1986–2011

In the late 1980s, having a mandate to provide knowledge and technology in order to increase the competitiveness and sustainability of the beef industry in British Columbia, the Station and its Experimental Farm at Prince George conducted research in the disciplines of range ecology, range management, plant physiology, alfalfa bloat, poisonous plants, soil management and fertility, agronomy, beef cattle nutrition, and feedlot studies.

The Station was officially renamed the Kamloops Range Research Farm in 1995. During 1995-1996, management of the Kamloops Range Research Farm passed to the Pacific Agri-Food Research Centre (PARC) at Summerland. In the following year, the Lethbridge Research Centre assumed management, being seen as a better fit because of its Land Resources Section, which also dealt extensively with range and beef cattle. This relationship to Lethbridge lasted until April 2004, when the administration returned to PARC at Summerland.

New Facilities

In 1989, a new agronomy building with offices, a growth chamber, and shops was built.

In 1996, a new office and laboratory building was completed. Numerous upgrades had been previously made to the main office and laboratory building's water, heating, and electric systems. The new building includes a laboratory for sample preparation and wet chemistry, and a separate lab for the operation of sophisticated equipment.

Research emphasized rangeland utilization, taking into consideration the balance of ecological and economic relationships among livestock and forage production, forestry, wildlife, water, recreation, and mining. Research also focused on the native grasslands, forested range, seeded forest clear-cuts and mine reclamation, as well as forage production and animal science.

Prince George Experimental Station

The Prince George Experimental Station, established in 1940, was located near the center of British Columbia and was the most northern departmental research facility in the province. The site consisted of four quarter-sections (160 acres each) of private land south of the city of Prince George that were purchased and consolidated into one property. Through the years it was known as the Prince George Experimental Farm.

The research facility was very active in soil science, horticulture, apiculture, agronomy, dairy, and animal husbandry. From 1948 to 1959, the Station's agricultural-demonstration activities took place at a number of illustration stations, which consisted of a variety of distinctive soil types and climatic conditions throughout the Central regions of B.C. Between 1940 and 1985, several researchers worked at the Experimental Station. By 1986, there was one researcher at the Prince George Experimental Station.

During the late 1980s and early 1990s most research was directed towards forage production and its utilization by cattle. Grasses, legumes, and grains such as barley and oats were evaluated in collaboration with the British Columbia Ministry of Agriculture and the British Columbia Forage Council. Many new and potential varieties of forages were evaluated to determine suitability and increase production for the region. Considerable work was directed at timothy, reed canary, and meadow foxtail grasses, which are more suitable for the regions heavier clay soils and the wet organic meadows of the Cariboo region. One legume that showed promise was Birdsfoot trefoil, but it was found to be too difficult to establish and manage for hay or grazing production. Soils work included the evaluation of the soil-testing of multi-element extractions, using soils from British Columbia and Alberta. It was determined that multi-nutrient extractions can be used successfully to test soil for plant nutrients. Soil adsorption of phosphorous was also studied to determine why the response of some phosphorous-deficient soils to this fertilizer element was limited.

Biosolids were demonstrated to be useful as an organic amendment for crop and soil. Over the years, as the numbers of employees, equipment, and farm animals decreased, the harvesting of the Station's forage was conducted using a share-cropping arrangement with a local producer.

New research at the Station ceased about 1991, with the transfer of the last research scientist and superintendent to Kamloops. A skeleton staff maintained some necessary activities at the Station, since some research plots associated with cooperative projects remained for a few more years. The last departmental employee left the Station in the summer of 1994. On March 31, 2000, the property was transferred to Indian and Northern Affairs Canada, and it was used as part of the treaty settlement with the Lheidli T'enneh First Nation.

In 2004, the Prairie Farm Rehabilitation Administration (PFRA) moved back into offices at the Kamloops Range Research Farm to assist researchers at Kamloops and Prince George in the development of facility water needs and in the improvement of watering facilities for beef cattle and wildlife on the rangelands.

Research highlights over the past 25 years

- Evaluated many grass and legume forage varieties for production and quality, and ranked them to help industry determine which to use within the various regions
- Reseeded many over-utilized areas using a rangeland drill that was developed in the 1970s and 1980s in conjunction with the British Columbia Ministry of Agriculture to establish crested wheatgrass and Russian ryegrass
- Advanced the understanding of poisonous range plants and their management to increase knowledge of poisonous compounds and their management

- Evaluated bloat-prevention products and the development of lower-incident-bloat alfalfa varieties
- Studied the beneficial uses of biosolids for reclamation of native grassland and mine land in conjunction with Metro Vancouver
- Evaluated the impact of molybdenum (Mo) through grazing studies and plant chemistry at reclaimed sites exhibiting high levels of Mo, and determined that levels much higher than suggested in the literature were safe for cattle and wildlife
- Determined that biosolids did not significantly increase the levels of dioxins and furans in the meat of cattle grazing on biosolid-applied land
- Studies showed that cattle grazing within watersheds did have an impact on water quality but that the largest sources of bacteria are from wildlife, especially birds or avian using bacterial source tracking of *E. coli*
- Implemented the Watershed Evaluation of Best Management Practices in the Salmon River watershed and studied the impact on water quality of fencing beef cattle out of the riparian area; additional studies looked at water quality, vegetation, macro-invertebrates, bacterial source tracking, ground water and the modeling of water flow and quality, and recently, water irrigation efficiency

Since 1935, the Research Farm has accumulated knowledge and developed technologies that have benefited British Columbia's beef cattle production. Though continuing to support applied research, the Research Farm altered its focus in 2011, and is now referred to as the Grassland Applied Technology Centre. The Agri-Environment Services Branch is taking the lead and is well positioned to continue to generate knowledge and technologies to the benefit of the industry while sustaining the natural resources important to the agricultural industry and society.

Pacific Agriculture Research Centre
Vancouver, British Columbia

Chris French, Research Scientist, Research Branch, Summerland

The Vancouver Research Station was established on the campus of the University of British Columbia in 1960. By 1986, the Station was recognized as an international centre for research in plant virology. As the original staff began to retire, new recruits arrived, attracted by the Station's reputation for research excellence, to undertake research on virus chemistry and physiology, plant pathology, and entomology. An important theme for research from 1986 to 1996 was the continuing co-operation of several scientific disciplines to support and develop the small-fruit industry in the Fraser Valley. The Station closed in 1996. The Station's national collections of monoclonal antibodies, viruses and antisera were transferred to Summerland.

The early years, 1960–1985

The Vancouver Research Station was established in 1960 on a 4-hectare site on the campus of the University of British Columbia (UBC) in Vancouver. Attached to the main building was a large greenhouse complex supported by a header house and workshop. The main theme of the new Station's research was plant virology.

The beginning of the second century of research, 1986-1996

In 1986, Vancouver celebrated its 25th anniversary and was recognized as an international centre for research in plant virology. In addition, there were very strong and complementary research programs in small fruit breeding, entomology and plant pathology. The Station's location on the UBC campus facilitated productive interactions with academic programs and faculty members. Several researchers held adjunct faculty appointments at UBC and supervised graduate students in addition to assisting with undergraduate teaching.

Vancouver fostered a culture of scientific excellence, interdisciplinary co-operation and direct service to the agricultural industry, and it was also an attractive location for international visiting researchers.

In 1986, the Virus Chemistry and Physiology Section focused its research on basic studies related to plant viruses, and on electron microscopy. In addition, applied research was conducted to identify the causal agent of Little Cherry Disease, a major problem for cherry growers in the British Columbia Interior.

The Plant Pathology Section focused on diseases caused by viruses and bacteria, plant breeding of small fruits, fungal pathology, and nematology. A major strength of the section was the integration of various specialists to develop and support the small fruit industry in the Fraser Valley. Potato disease (viruses and bacteria) programs were also important. Useful interaction occurred with regulators from Food Production and Inspection Branch (now the Canadian Food Inspection Agency). As well, the development and maintenance of virus-free seed potato production took place in the Pemberton Valley.

The Entomology Section conducted research on aphid taxonomy and ecology, control of insects affecting vegetables and berry crops, insect virology and pesticide chemistry.

Research at Vancouver was also supported by a well-equipped electron microscopy facility with two technicians, a monoclonal antibody laboratory, a librarian and a regional statistician.

An 8.5-hectare field site at Abbotsford, 40 kilometres east of Vancouver, became part of the Station in 1989. In 1994, the Station's name was changed to the Pacific Agriculture Research Centre, and Agassiz began reporting to it.

In 1996, the Pacific Agriculture Research Centre ceased operations, and ownership of the building was transferred to UBC. Key personnel were transferred to the facilities of the Pacific Agri-Food Research Centre in Summerland and Agassiz.

An important theme for Vancouver from 1986 to 1996 was the continuing co-operation of several scientific disciplines to support and develop the small-fruit industry in the Fraser Valley. A Vancouver plant breeder was responsible for the successful development and introduction of several varieties of strawberry and raspberry, many of which are in production today. The small fruit breeding program was supported by specialists in virology, entomology, fungal pathology, and nematology.

A national collection of monoclonal antibodies, viruses and antisera was developed and maintained at Vancouver and made available for distribution. The collections were transferred to Summerland when Vancouver closed.

Research highlights between 1986 and 1996

- Used electron microscopy to demonstrate virus particles associated with Little Cherry Disease; this was pioneering work in the eventual characterization of the viruses that cause the disease
- Developed monoclonal antibodies to:
    - detect potato leaf roll virus and soft-rot bacteria in potato
    - identify the necrotic strain of potato virus Y (PVY^{n}), which helped the Canadian Food Inspection Agency regulate the virus in Eastern Canada
    - distinguish between the virulent and non-virulent strains of *Leptospheria maculans*, the causative agent of blackleg of canola
- Obtained complete nucleotide sequences of cucumber necrosis virus and melon necrotic spot virus

- Discovered that flavonoids were potent inhibitors of a range of plant viruses, a development that led to applications for the elimination of tree fruit viruses
- Carried out leading-edge research on the development of transgenic potatoes with resistance to potato viruses such as potato leaf roll virus and potato virus S, using transformation with the coat protein gene
- Developed and released the Shuswap strawberry and Tulameen red raspberry
- Developed management techniques to control two spotted spider mites in strawberries
- Developed antibodies to identify the infection of strawberry by strawberry mild yellow edge virus in advanced breeding selections
- Controlled two spotted spider mites using the native predacious mite *Amblyseius fallacis*
- Detected tomato ringspot virus in tubular structures, which helped to explain movement of the virus from cell to cell
- Elucidated the role of the coat protein of cucumber necrosis virus, which was required for a specific interaction with zoospores of its fungal vector, *Olpidium radicale*
- Used a DNA-based diagnostic system to detect and identify species of *Pythium*, some of which are important pathogens of vegetables. This system has also been used to advance the taxonomy of many fungal pathogens

Throughout its history, the Pacific Agriculture Research Centre was a national and international resource for plant virology, plant pathology, and entomology. The cornerstone of its reputation was scientific excellence, combined with the development of many practical contributions that benefited not only agriculture in British Columbia but across Canada.

Saanichton Research and Plant Quarantine Station
Sidney, British Columbia

Chris French, Research Scientist, Research Branch, Summerland

The Saanichton Experimental Station opened in 1912, became a Research Station in 1961, and in 1980 was renamed the Saanichton Research and Plant Quarantine Station. By 1986, it was the centre for ornamental and greenhouse research in British Columbia and responsible for the post-entry plant quarantine program for Canada. The Station conducted research in floriculture, developed new greenhouse technology and advanced the kiwi as a fruit that could be successfully grown in Canada. The Department discontinued ornamental research in 1987, and the Station was transferred to the Food Production and Inspection Branch. The facility is now called the Centre for Plant Health, and remains operational today as part of the Canadian Food Inspection Agency, with activities in plant quarantine and related research.

The early years, 1912–1985

In 1912, 50 hectares of land were acquired near Saanichton, 30 kilometres north of Victoria, for the creation of an experimental station to serve the needs of agriculture on Vancouver Island.

Research was conducted in floriculture, greenhouse and field vegetable production, nursery plant production, virus eradication from grapevines, the identification of viruses from ornamentals, and the biological control of pests and diseases. Ornamental research concentrated on floricultural crops such as *Chrysanthemum*, *Gerbera* and *Alstroemeria*. Nursery crop production specialized in the propagation and production of rhododendrons.

Kiwifruit was introduced as a potential alternative crop for British Columbia. With the help of a visiting scientist from New Zealand, a large kiwifruit planting was established, demonstrating a range of training methods, cold hardiness under local climatic conditions, and propagation using tissue culture.

New greenhouse technology was developed, with the construction of a solar heated structure, energy conservation via thermal blankets, and a computerized climate control system, all of which were new technologies at the time.

Greenhouse vegetable research concentrated on a comparison of various hydroponic systems for the production of tomatoes and green peppers and demonstrations of the advances in energy conservation technologies in the main greenhouses.

Research in the area of biological control—at this time in an early stage of commercial development—studied the use of beneficial mites (*Amblyseius cucumeris*) to control thrips (*Frankliniella occidentalis* Pergande), a major pest of greenhouse cucumbers in British Columbia.

In 1961, the Experimental Station was renamed the Saanichton Research Station and continued to focus on ornamental and greenhouse vegetable research. In 1980, it became the Saanichton Research and Plant Quarantine Station with dual responsibility—first, for ornamental and greenhouse vegetable research for British Columbia and second, for the post-entry plant quarantine program for Canada.

The quarantine program conducted testing for virus infection of all imported tree fruit, grape, and small-fruit plant material that was not accompanied by an acceptable phytosanitary certificate. It was also responsible for verifying the reliability of recognized foreign certification programs for grapes and treefruit nursery stock, by testing plant samples from imported commercial shipments for virus infection (audit program). Tests were conducted on promising selections from Canadian treefruit and grape breeders to ensure that original releases to the industry were free from detectable viruses. The Station established plantings of valuable virus-free treefruit and grapes as a repository for Canadian industries and research programs.

The beginning of the second century of research, 1986–1987

By 1986, Saanichton Research and Plant Quarantine Station had six researchers from Research Branch working on ornamental and vegetables. They shared the facility with three colleagues in the Post-Entry Quarantine Program for treefruit and grapevines operated by the Food Production and Inspection Branch.

Two viruses infecting grapevine—grapevine fanleaf virus and arabis mosaic virus—were eliminated from tissue cultures, using an alternating heat therapy treatment. Three publications on the occurrence of viruses in ornamental plants were published in 1986.

In 1987, Research Branch ceased operations at Saanichton, and the management of the Station was transferred to the Food Production and Inspection Branch. The Station was renamed the Centre for Plant Health and remains operational today as a plant quarantine and research facility for the Canadian Food Inspection Agency.

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Appendix

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1. Names of Ministers, Deputy Ministers, Associate Deputy Ministers and Assistant Deputy Ministers, Research from 1986 to 2011

AGRICULTURE AND AGRI-FOOD CANADA*

MINISTERS	
Hon. J. Wise	1984-1988
Hon. D.F. Mazankowski	1988-1991
Hon. W.H. McKnight	1991-1993
Hon. C.J. Mayer	1993
Hon. R. Goodale	1993-1997
Hon. L. Vanclief	1997-2003
Hon. R. Speller	2003-2004
Hon. A. Mitchell	2004-2006
Hon. C. Strahl	2006-2007
Hon. G. Ritz	2007-2011

DEPUTY MINISTERS	
Mr. P.J. Connell	1982-1986
Mr. J.-J. Noreau	1986-1992
Mr. R.A. Wright	1992-1994
Mr. R.J. Protti	1994-1996
Mr. F.A. Claydon	1996-2000
Mr. S. Watson	2000-2004
Mr. L. Edwards	2004-2007
Ms.Y. Baltacioğlu	2007-2009
Mr. J. Knubley	2009-2011

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* *In 1993, Agriculture Canada was renamed Agriculture and Agri-Food Canada.*

ASSOCIATE DEPUTY MINISTERS

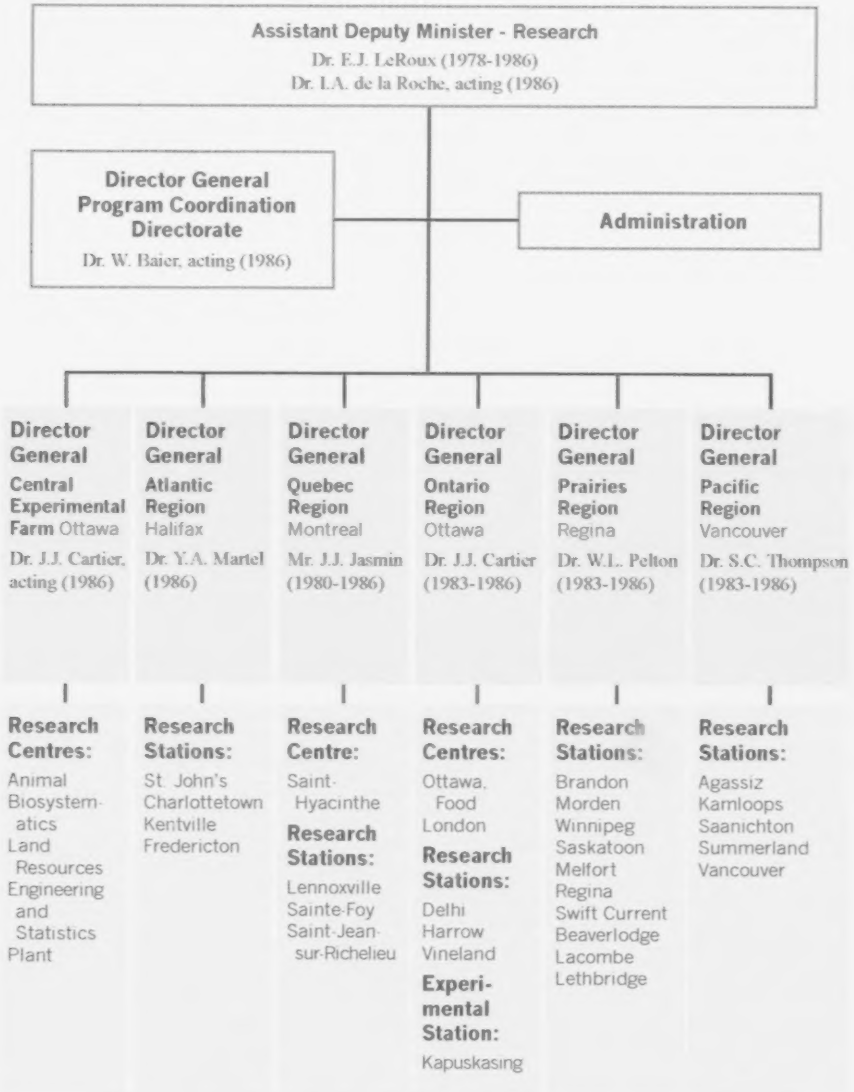
Ms. M. Comeau	1997-1999
Ms. D. Vincent	1999-2003
Ms. C. Ouimet	2004-2007
Ms. L. Forand	2008-2009
Ms. A. Lyon	2009-2011
Mr. C. Carrière	2011

ASSISTANT DEPUTY MINISTERS - RESEARCH

Dr. E.J. LeRoux	1978-1986
Dr. I.A. de la Roche, acting	1986
Dr. A.O. Olson	1987-1991
Dr. B.J. Morrissey	1992-2000
Dr. G.D. Dorrell, acting	2001-2003
Dr. B.A. Archibald	2003-2004
Dr. Y.A. Martel, acting	2005
Dr. M. Fortin	2006-2011
Ms. J. Aylard, acting	2011

2. Research Branch Structure and its Directors General

2.1 Period 1986



Assistant Deputy Minister - Research
Dr. E.J. LeRoux (1978-1986)
Dr. I.A. de la Roche, acting (1986)

Director General Program Coordination Directorate
Dr. W. Baier, acting (1986)

Administration

Director General
Central Experimental Farm Ottawa
Dr. J.J. Cartier, acting (1986)

Research Centres:
Animal
Biosystematics
Land Resources
Engineering and Statistics
Plant

Director General
Atlantic Region
Halifax
Dr. Y.A. Martel (1986)

Research Stations:
St. John's
Charlottetown
Kentville
Fredericton

Director General
Quebec Region
Montreal
Mr. J.J. Jasmin (1980-1986)

Research Centre:
Saint-Hyacinthe

Research Stations:
Lennoxville
Sainte-Foy
Saint-Jean-sur-Richelieu

Director General
Ontario Region
Ottawa
Dr. J.J. Cartier (1983-1986)

Research Centres:
Ottawa, Food
London

Research Stations:
Delhi
Harrow
Vineland

Experimental Station:
Kapuskasing

Director General
Prairies Region
Regina
Dr. W.L. Pelton (1983-1986)

Research Stations:
Brandon
Morden
Winnipeg
Saskatoon
Melfort
Regina
Swift Current
Beaverlodge
Lacombe
Lethbridge

Director General
Pacific Region
Vancouver
Dr. S.C. Thompson (1983-1986)

Research Stations:
Agassiz
Kamloops
Saanichton
Summerland
Vancouver

2.2 Period of 1987-1996

Assistant Deputy Minister - Research
Dr. A.O. Olson (1987-1991) / Dr. J.B. Morrissey (1992-1996)

Director General - Priorities and Strategies Directorate
Dr. I.A. de la Roche (1987)

Director General - Strategies and Planning Directorate
D.F. Kirkland (1988-1990)
J.M. Ferguson-Milne (1990-1994)
P. Hall, acting (1995-1996)

Director General - Research Coordination Directorate
Dr. C.B. Willis (1988-1991)
Dr. G.M. Weaver (1992-1994)
Dr. J.-C. St-Pierre (1995-1996)

Director General
Eastern Region
Ottawa
Dr. Y.A. Martel (1987-1996)

1987-1992
Research Centres:
- Saint-Hyacinthe
- London

Research Stations:
- St. John's
- Charlottetown
- Kentville
- Fredericton
- Lennoxville
- Sainte-Foy
- Saint-Jean-sur-Richelieu
- Delhi
- Harrow
- Vineland

Experimental Farm:
- Kapuskasing

1993-1996
Research Centres:
- St. John's
- Charlottetown
- Kentville
- Fredericton
- Lennoxville
- Harrow
- Sainte-Foy
- Saint-Jean-sur-Richelieu
- Saint-Hyacinthe
- London

Director General
Central Region
Ottawa
Dr. J.J. Cartier (1987-1988)
Dr. J.-C. St-Pierre (1988-1995)
Dr. D.G. Dorrell (1995-1996)

1987-1992
Research Centres:
- Animal
- Biosystematics
- Food
- Land Resources
- Plant
- Engineering and Statistics

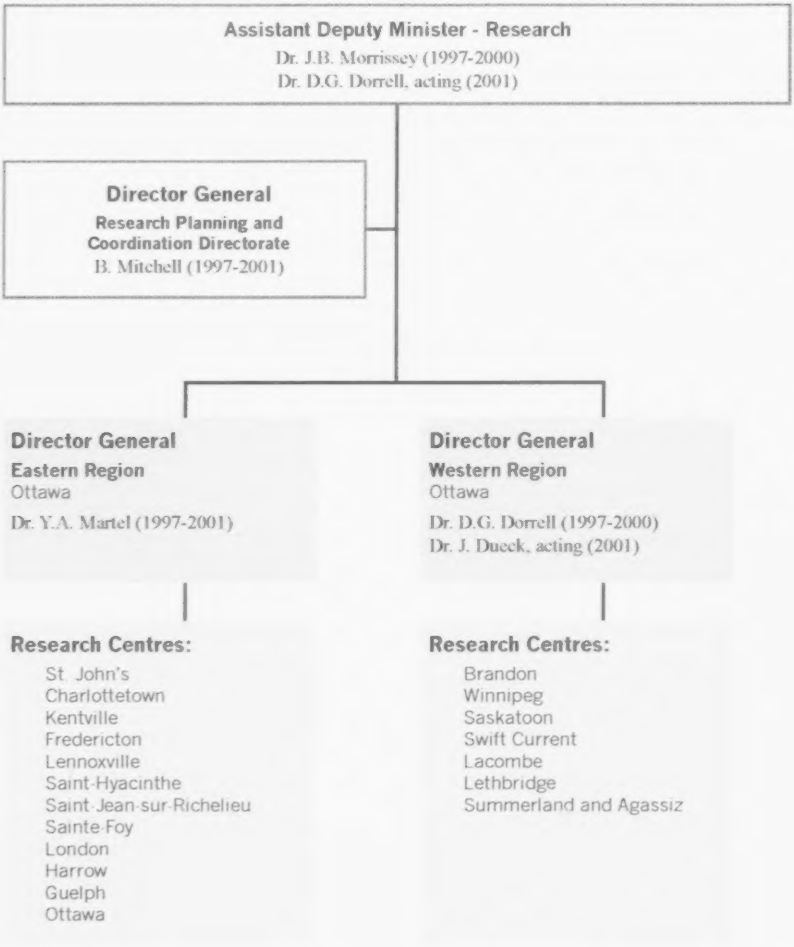
1993-1996
Research Centres:
- Plant
- Land and Biological Resources
- Food and Animal

Director General
Western Region
Ottawa
Dr. W.L. Pelton (1987-1988)
Dr. D.G. Dorrell (1989-1996)

1987-1992
Research Stations:
- Brandon
- Morden
- Winnipeg
- Melfort
- Regina
- Saskatoon
- Swift Current
- Beaverlodge
- Lacombe
- Lethbridge
- Agassiz
- Kamloops
- Summerland
- Vancouver
- Saanichton

1993-1996
Research Centres:
- Brandon
- Morden
- Winnipeg
- Saskatoon
- Swift Current
- Beaverlodge
- Lacombe
- Lethbridge
- Agassiz
- Summerland
- Vancouver

2.3 Period of 1997-2001



Assistant Deputy Minister - Research
Dr. J.B. Morrissey (1997-2000)
Dr. D.G. Dorrell, acting (2001)

Director General
Research Planning and Coordination Directorate
B. Mitchell (1997-2001)

Director General
Eastern Region
Ottawa

Dr. Y.A. Martel (1997-2001)

Research Centres:

- St. John's
- Charlottetown
- Kentville
- Fredericton
- Lennoxville
- Saint-Hyacinthe
- Saint-Jean-sur-Richelieu
- Sainte-Foy
- London
- Harrow
- Guelph
- Ottawa

Director General
Western Region
Ottawa

Dr. D.G. Dorrell (1997-2000)
Dr. J. Dueck, acting (2001)

Research Centres:

- Brandon
- Winnipeg
- Saskatoon
- Swift Current
- Lacombe
- Lethbridge
- Summerland and Agassiz

2.4 Period of 2002-2007

Assistant Deputy Minister - Research
Dr. D.G. Dorrell, acting (2002-2003) / Dr. B.A. Archibald (2003-2005)
Dr. Y.A. Martel, acting (2005) / Dr. M. Fortin (2006-2007)

Chief Scientist, International
International Scientific Cooperation Bureau
Dr. Y.A. Martel (2003-2007)

Director
Office of Intellectual Property and Commercialization
Dr. J. Culley (2003-2007)

Director General
Research Planning and Coordination Directorate
Dr. J. Culley, acting (2002)
Dr. G. Rousselle, acting (2003)
Science Secretariat
Dr. M.L.C. Deslauriers, acting (2004-2005)
Science Bureau
Dr. G. Saindon (2005-2007)

Director General
National Program: Sustainable Production Systems
Dr. S.D. Morgan Jones (2002-2007)

Director General
National Program: Environmental Health
Dr. J.-M. Deschênes, acting (2002)
Dr. C.W. Lindwall (2003-2007)
Dr. R. Butts, acting (2007)

Director General
National Program: Food Safety and Quality
Ms. A. St-Yves, acting (2002)
Dr. D.R.C. Bailey (2003-2004)
Dr. G. Saindon, acting (2005)
Dr. G. Rousselle, acting (2005)
Dr. P. Silva (2006-2007)

Director General
National Program: Bioproducts and Bioprocesses
Dr. G. Neish (2002-2007)

2002-2004

Science themes:
- Field and forage crops
- Cultivar creation and other genetic improvement
- Cereals and oilseed crops
- Livestock production system
- Animal behaviour and welfare

Science themes:
- Biodiversity
- Integrated pest management
- Genomics and biotechnology
- Quality of water resources
- Air quality
- Nutrients and organic residues
- High economic return plants

Science themes:
- Food safety support and regulation
- Response to consumer expectations concerning food quality
- New products and improved processes
- Nutritional quality improvements

Science themes:
- Special products and bioprocesses
- Bio-energy products and other biomass related processes
- Genomic bio-informatics and other types of bio-information

2004-2007

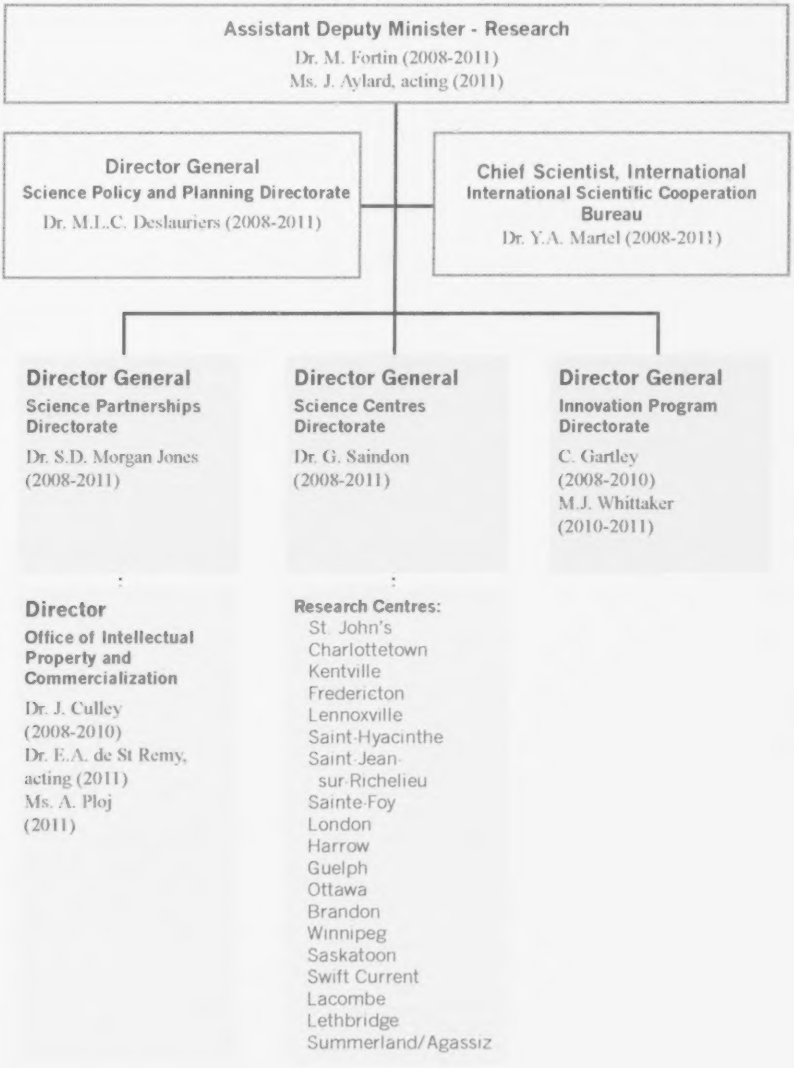
Science themes:
- Crop genetic enhancement
- Crop production systems
- Livestock production systems

Science themes:
- Biodiversity
- Integrated pest management
- Soil water and air quality

Science themes:
- Food safety and processing
- Food quality and nutrition

Science themes:
- Bio-based products and bioprocesses
- Genomics and biotechnology

2.5 Period of 2008-2011



Assistant Deputy Minister - Research
Dr. M. Fortin (2008-2011)
Ms. J. Aylard, acting (2011)

Director General
Science Policy and Planning Directorate
Dr. M.L.C. Deslauriers (2008-2011)

Chief Scientist, International
International Scientific Cooperation Bureau
Dr. Y.A. Martel (2008-2011)

Director General
Science Partnerships Directorate
Dr. S.D. Morgan Jones
(2008-2011)

Director
Office of Intellectual Property and Commercialization
Dr. J. Culley
(2008-2010)
Dr. E.A. de St Remy, acting (2011)
Ms. A. Ploj
(2011)

Director General
Science Centres Directorate
Dr. G. Saindon
(2008-2011)

Research Centres:
St. John's
Charlottetown
Kentville
Fredericton
Lennoxville
Saint-Hyacinthe
Saint-Jean-sur-Richelieu
Sainte-Foy
London
Harrow
Guelph
Ottawa
Brandon
Winnipeg
Saskatoon
Swift Current
Lacombe
Lethbridge
Summerland/Agassiz

Director General
Innovation Program Directorate
C. Gartley
(2008-2010)
M.J. Whittaker
(2010-2011)

3. The National Science Programs and the National Science Themes, 2002-2011

3.1 From 2002 to 2004, Research Branch had four national science programs managed by National Program Leaders (Directors General) and 19 national science themes, as presented in Table 2.4, managed by National Science Theme Leaders. Former directors of research centres and senior researchers have occupied the positions of National Science Theme Leaders in an acting capacity.

J. Bole, Ph.D.

R. Butts, Ph.D.

R. Chagnon, Eng.

D. Demars, Ph.D.

C. Deslauriers, Ph.D.

L. Dwyer, Ph.D.

B. Grace, Ph.D.

P. Hicklenton, Ph.D.

W. Johnson, Ph.D.

R. Kucey, Ph.D.

P. Piyasena, Ph.D.

J. Richards, Ph.D.

G. Rousselle, Ph.D.

G. Saindon, Ph.D.

V. Stevens, Ph.D.

J. Stewart, Ph.D.

J. Surprenant, Ph.D.

C. Toupin, Ph.D.

G. Whitfield, Ph.D.

3.2 From 2004 to 2007, Research Branch had four national science programs managed by Directors General and 10 Science Themes managed by Science Directors.

A. Sustainable production systems:

Crop genetic enhancement

P. Burnett, Ph.D.	2004
J. Stewart, Ph.D.	2005-2007

Crop production systems

D. Wall, Ph.D.	2004-2005
P. Hicklenton, Ph.D.	2005-2007

Livestock production systems

J. Surprenant, Ph.D.	2004-2007

B. Environmental health:

Biodiversity

B. Grace, Ph.D.	2004-2007

Integrated pest management

G. Whitfield, Ph.D.	2004-2007

Soil, water and air quality

R. Butts, Ph.D.	2004-2007
C. Lemieux, Ph.D., acting	2007

C. Food safety and quality:

Food safety and processing

F. Nattress, Ph.D., acting	2004
J. Lynch, Ph.D.	2005
G. Piette, Ph.D.	2006-2007

Food quality and nutrition

P. Silva, Ph.D.	2004-2007
G. Piette, Ph.D., acting	2007

D. Bioproducts and bioprocesses:

Bio-based products and processes

J. Brandle, Ph.D., acting	2004-2006
C. Deslauriers, Ph.D.	2007
M. Marcotte, Ph.D.	2007

Genomics and biotechnology

D. Kurdika, Ph.D.	2004
L. Dwyer, Ph.D.	2005-2007

3.3 From 2008 to 2011, there were changes in the names of science themes led by Science Directors who were also made responsible for research scientists of at least one research centre. The following was the situation in 2011:

Soil and Water Resources
J. Boisvert, Ph.D.

Biodiversity and Northern Agriculture
B. Grace, Ph.D.

Crop Production Systems
P. Hicklenton, Ph.D.

Air Quality and Adaptation to Climate Change
C. Lemieux, Ph.D.

Food and Health
M. Marcotte, Ph.D.

Bioproduct Platforms and Genomics
P. McCaughey, Ph.D.

Food Production Systems
G. Piette, Ph.D.

Plant Germplasm Enhancement
J. Stewart, Ph.D.

Livestock Production Systems
J. Surprenant, Ph.D.

Crop Protection Systems
G. Whitfield, Ph.D.

4. Research Centres and their Managers

Atlantic Cool Climate Crop Research Centre
St-John's, Newfoundland and Labrador
Directors:

H.R. Davidson, Ph.D.	1984-1986
K.G. Proudfoot, M.Agr., acting	1987-1990
M.D. Sudom, M.S.A.	1991-1993
P.L. Dixon, Ph.D., acting	1994-1995
J.E. Richards, Ph.D.	1996-2002

Research Managers:

P.L. Dixon, Ph.D., acting	2003-2004
S. Todd, M.Sc., acting	2004-2005
D. McKenzie, Ph.D., acting	2005
A. Kwabiah, Ph.D., acting	2005-2006
S. Todd, M.Sc.	2006-2011

Science Director:

P. Hicklenton, Ph.D.	2008-2011

Crops and Livestock Research Centre
Charlottetown, Prince Edward Island

Directors:

L.B. Macleod, Ph.D.,	1970-1990
C.B. Willis, Ph.D.	1991-1995
J. A. Ivany, Ph.D., acting	1996
D.R.C. Bailey, Ph.D.	1996-1998
J. A. Ivany, Ph.D., acting	1999
M.L.C. Deslauriers, Ph.D.	1999-2002

Research Managers:

T.A. Van Lunen, Ph.D., acting	2003-2005
M. Proulx, M.P.A.	2005-2009
R.A. Martin, Ph.D., acting	2009-2010
M. Rodriguez, Ph.D.	2010-2011

Science Director:

P. Hicklenton, Ph.D.	2008-2011

Atlantic Food and Horticulture Research Centre
Kentville, Nova Scotia

Directors:

G.W. Weaver, Ph.D.	1979-1990
K.G. Proudfoot, M.Agr., acting	1991
P.W. Johnson, Ph.D.	1992-2002

Research Managers:

R. Bush, Ph.D.	2003-2008
D.M. Hodges, Ph.D., acting	2008-2009
K. Mackenzie, Ph.D., acting	2009
D.M. Hodges, Ph.D.	2010-2011

Science Director:

P. Hicklenton, Ph.D.	2008-2011

Potato Research Centre
Fredericton, New Brunswick

Directors:

Y.A. Martel, Ph.D.	1984-1986
G.C. Misener, Ph.D., acting	1986
D.K. McBeath, Ph.D.	1987-1995
C.B. Willis, Ph.D., acting	1996
P. Milburn, Ph.D., acting	1996
G. Saindon, Ph.D.	1996-2000
R. Butts, Ph.D.	2000-2002

Research Managers:

P. Milburn, Ph.D.	2003-2006
J.-P. Privé, Ph.D., acting	2007
J.A. Millette, Ph.D.	2008-2010
J.E. Hurley, M.Sc.	2011

Science Directors:

J.-P. Privé, Ph.D., acting	2008
C. Lemieux, Ph.D.	2009-2011

Soils and Crops Research and Development Centre
Quebec City (Sainte-Foy), Quebec

Directors:

S.J. Bourget, Ph.D.	1968-1990
A. St-Yves, M.Sc.	1991-1998
G. Rousselle, Ph.D.	1999-2002

Research Managers:

R. Michaud, Ph.D., acting	2003-2005
M. Germain, M.Sc.	2006-2009
C. Lapierre, M.Sc., acting	2009
G. Levasseur, M.Sc.	2010-2011

Science Directors:

J. Surprenant, Ph.D.	2008
C. Lemieux, Ph.D.	2009-2011

Dairy and Swine Research and Development Centre
Sherbrooke (Lennoxville), Quebec

Directors:

J.-C. St-Pierre, Ph.D.	1984-1988
J.-M. Deschênes, Ph.D.	1989-1998
J. Surprenant, Ph.D.	1999-2002

Research Managers:	
D. Massé, Ph.D.	2003-2005
J.P. Charuest, M.Sc.	2005-2006
A. Giguère, Ph.D.	2006-2011
Science Director:	
J. Surprenant, Ph.D.	2008-2011

Food Research and Development Centre
St-Hyacinthe, Quebec

Directors:	
R.R. Riel, Ph.D.	1983-1988
C.B. Aubé, Ph.D.	1988-1998
G. Rousselle, Ph.D., acting	1998
A. St-Yves, M.Sc.	1998-2001
C. Toupin, Ph.D., acting	2001-2002
Research Managers:	
C. Toupin, Ph.D.	2003-2010
A. Houde, Ph.D.	2011
Science Director:	
G. Piette, Ph.D.	2008-2011

Horticulture Research and Development Centre
Saint-Jean-sur-Richelieu, Quebec

Directors:	
C.B. Aubé, Ph.D.	1980-1987
P. Martel, Ph.D., acting	1988
D. Demars, Ph.D.	1989-2002
Research Manager:	
R. Chagnon, Eng.	2003-2011
Science Director:	
J. Surprenant, Ph.D.	2008-2011

Guelph Food Research Centre
Guelph, Ontario

Director:	
G. Poushinsky, M.Sc.	2000-2002
Research Managers:	
P. Piyasena, Ph.D., acting	2003-2005
M. Baxi, Ph.D.	2006-2008
P. Piyasena, Ph.D.	2009-2011

Science Director:

G. Piette, Ph.D.	2008-2011

Greenhouse and Processing Crops Research Centre
Harrow, Ontario

Directors:

C.F. Marks, Ph.D.	1981-1990
P.W. Johnson, acting	1991
D.R. Menzies, Ph.D.	1992-1994
G.H. Whitfield, Ph.D.	1995-2002

Research Managers:

J. Warner, Ph.D., acting	2003-2005
A. Hamill, Ph.D., acting	2006
P. Piyasena, Ph.D.	2007-2008
A. Svircev, Ph.D., acting	2009-2010
R. Sharma, Ph.D.	2010-2011

Science Director:

G. Whitfield, Ph.D.	2008-2011

Southern Crop Protection and Food Research Centre
London, Ontario

Directors:

H.V. Morley, Ph.D.	1978-1990
C.F. Marks, Ph.D.	1991-2000
G. Saindon, Ph.D.	2000-2002

Research Managers:

D. Brown, Ph.D.	2003-2006
K. Volkmar, Ph.D.	2006-2011

Science Director:

G. Whitfield, Ph.D.	2008-2011

Eastern Cereal and Oilseed Research Centre
Ottawa, Ontario

Directors:

J. Dueck, Ph.D.	1996-1997
H. Voldeng, Ph.D., acting	1997
J.-M. Deschênes, Ph.D.	1998-2001
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